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VOLUME 30 4 NUMBER 1

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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1907-1908

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1907-1908

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PHILIP DE C. BALL
E. F. MILLER

On Society History

JOHN E. SWEET
H. H. SUPLEE
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H. H. SUPLEE
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G. M. BASFORD
F. R. HUTTON
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PROCEEDINGS

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 30 JANUARY 1908 NUMBER 1

THE next monthly meeting, January 14, 1908, will be one of importance to railroad officials and all interested in the various kinds of train lighting. There will be a general presentation of the subject by Mr. R. M. Dixon, President of the Safety Car Heating and Lighting Company. The discussion will be opened by Mr. Henry K. Brooks and by other engineers, each describing a different system of lighting, so that the matter will assume a general aspect and not be confined to any one system. In addition, there will be in operation several different systems, namely, the Pintsch mantle, the vapor mantle, a new acetylene system, and several varieties of axle lighting by electricity (generated by dynamo on the truck of the car) with their regulating and governing mechanism. This will be a good opportunity for those interested in this subject to see these different lights in actual operation and obtain a description of their mechanism.

Mr. Henry K. Brooks, Chief Engineer of The United States Light and Heating Company, will open the discussion and will use in illustration diagrams showing methods of dynamo control and parts of an electric car lighting equipment with automatic battery switch, regulating apparatus, an automatic polarity reversing switch, brush holders, etc.

The automatic current regulator will be operated, showing the method and range of regulation under varying speeds of the train. There will also be exhibited in operation an automatic polarity reversing switch. In these devices centrifugal and gravitation forces are ingeniously utilized.

THE NEXT SPRING MEETING

We can announce the acceptance of the invitation of our Vice President, Mr. Alex. Dow and of Mayor Thompson to hold the next Spring Meeting in Detroit, Michigan. Complete details will be given later, and any authors desiring opportunity to present papers should forward them at once, as it is no longer practicable to promise to receive papers up to a certain number of days before a meeting. The responsibilities of the Meetings Committee are too great to permit of considering indefinite promises of papers.

NOTES FROM THE ANNUAL MEETING

Those who did not attend the Annual meeting this year missed an opportunity to gain the inspiration which such a gathering of the profession affords.

The facilities of the new headquarters, which every member may enjoy with the pride of ownership, rendered the meeting an unqualified success.

Registration, exchange of railway certificates, distribution of literature, mail, etc., were effected in the main foyer on the ground floor. In this spacious entrance also friend greeted friend, and new acquaintanceships were formed which is a main benefit of the Society's functions.

To say this was the largest meeting is not to give the true measure of its worth. Over thirteen hundred members and guests were registered.

The Presidential address, appearing in the previous number of Proceedings, expressed the wider usefulness and larger activities which the Society is to undertake.

Carrying out the successful ideas of the Meetings Committee of a year ago, symposiums on a few subjects were the features of this meeting. This was pronounced satisfactory by all. In this manner a member will very soon have in his Transactions a complete record of the particular art treated at the time of the meeting the papers were presented.

So interesting were the sessions on Gas Power that a separate section was carried on simultaneously with the symposium on Foundry Practice. The building, with its eight auditoriums, readily lended itself, not only to the meetings, but as an incident, the stereopticon was used also in both meetings.

At another place we mention the birth of a prospective Section in Gas Power engineering of the Society as an outcome of the interest aroused at the meeting.

The new President had the unique and extraordinary honor of being escorted to the rotunda by the oldest and most esteemed of our Honorary Members, Messrs. John E. Sweet and John Fritz. The presence of the Honorary Members at our meetings and the reception Thursday night added greatly to the interest of the Annual Convention.

Wednesday evening an instructive as well as entertaining address on the process in color photography, was given by Mr. F. E. Ives, Past President and Honorary Member of the New York Camera Club. He was assisted by Mr. A. R. Stieglitz, also a gentleman of international reputation in this field of research.

A member of the Publication Committee, Mr. H. F. J. Porter, kindly prepared for the members an historical sketch which greatly assisted one to appreciate the details of the address and exhibits.

Another feature of the meeting, showing the care with which the Meetings Committee had provided for the interest of attending members, was an excursion, by the courtesy of Mr. Charles M. Jacobs, Chief Engineer of the Hudson Companies, through the tunnel from Hoboken under the Hudson River to Christopher Street, New York. This is the completed tunnel, begun over a generation ago by Haskin. A complete illustrated pamphlet, covering both the historical and technical features, was also prepared by the Meetings Committee.

Copies of both "Color Photography" and "The Hudson Tunnels" will be mailed on application.

INVITATIONS

The members of the Society were the recipients of further invitations to visit places of engineering interest in the vicinity of New York.

J. H. McGraw, Esq., President of the McGraw Publishing Company, invited the members to visit his 6-story building constructed entirely of reinforced concrete, and of unique construction. This building is not only a complete office building, but in addition contains the Times Square Sub-Station of the New York Post Office, and also the complete printing establishment of the McGraw Publishing Company.

Mr. F. H. Stillman, Member of the Society, of the firm of The Watson-Stillman Company, exhibited at his works at Aldene, New Jersey, a 300 horse power gas producer and engine. Several parties availed themselves of this invitation.

Mr. D. L. Hough, member of the Society and President of The United Engineering and Contracting Company, gave personal supervision of parties visiting the Pennsylvania Company's cross-town tunnel work.

RECEPTION

The reception Thursday evening, usually held at Sherry's, was given in the building of the Society.

ELECTION OF OFFICERS

The following officers for the ensuing year were found to be elected by the Tellers of Election and so declared at the meeting, December 3.

President

M. L. HOLMAN

Vice-Presidents

L. P. BRECKENRIDGE FRED. J. MILLER

ARTHUR WEST

Managers

WM. L. ABBOTT ALEX. C. HUMPHREYS

HENRY G. STOTT

Treasurer

WM. H. WILEY

ELECTION OF MEMBERS

According to Statutory requirement, the names balloted for membership on June 10, July 25, and November 28 were formally declared elected, with a few exceptions, by the President at the business meeting of the Society on December 4.

SECTION ON GAS POWER ENGINEERING

At the conclusion of the Annual meeting, the following members petitioned the Society for permission under the Constitution to form a section:

Albert A. Cary, New York.
Jas. V. V. Colwell, New York.
Geo. D. Conlee, Ithaca, N. Y.
R. H. Fernald, Cleveland, O.
Alex. R. Goldie, Ontario, Can.
John A. Laird, St. Louis, Mo.
J. S. Lane, Brooklyn, N. Y.
Fred R. Low, New York.
Charles E. Lucke, New York.
D. T. MacLeod, Camden, N. J.
R. E. Mathot, Brussels, Belgium.
Edward Robinson, Burlington, Vt.
Geo. I. Rockwood, Worcester, Mass.
C. W. Scribner, New York.
Arthur K. Spotton, Galt, Canada.
F. H. Stillman, New York.
H. H. Suplee, New York.

Others, guests of the Society, signing the petition:

J. C. Barnaby, New York.
W. B. Chapman, New York.
W. R. Huttinger, Beverly, N. J.
F. E. Junge, Berlin, Germany.
L. B. Lent, New York.
J. W. Lowell, New York.
G. F. F. Osborne, Toronto, Canada.
A. F. Stillman, New York.
Frank C. Tryon, New York.
A. J. Verkouterew, Flushing, L. I.
C. T. Wilkinson, Schenectady, N. Y.

Mr. H. H. Suplee was chosen Secretary of the informal meeting and presented the matter to the Council. The Council cordially received the petition and immediately appointed a Committee on Affiliated Societies, consisting of:

F. R. Huttton, *Chairman*,
Alex. C. Humphreys,
R. H. Fernald,
F. W. Taylor,
H. H. Suplee.

to confer with a Committee of the members and arrange the details in conformity with the rules of the Constitution already prepared for the formation of sections.

The President's address, dealing with the phase of the Society's broader usefulness involved in extending its interest in this manner, was also referred to this Committee for consideration and report.

SOCIETIES OFFICIALLY REPRESENTED AT THE ANNUAL MEETING

La Société des Ingenieurs Civils de France was officially represented by M. Delafond.

The National Fire Protection Association was represented by their Editor, Mr. Henry A. Fiske.

REUNION OF WORCESTER POLYTECHNIC INSTITUTE

A pleasing association with the Annual meeting is the custom of the Alumni of the Worcester Polytechnic Institute, many of whom are prominent in the Society, of holding a dinner on the Friday evening

of the week. This dinner was largely attended and many enthusiastic speeches were given.

HONORARY SECRETARY

The Council, in further appreciation of the service of Professor F. R. Hutton, appointed him Honorary Secretary for the ensuing year.

JOHN FRITZ MEDAL COMMITTEE

Professor F. R. Hutton was selected by the Committee to fill the vacancy on the John Fritz Medal Committee. This medal thus far has been awarded to John Fritz, Lord Kelvin (just deceased), George Westinghouse and Dr. Alexander Graham Bell.

DENVER MEMBERS MEETING

In the Engineering Record of November 30, is an account of a dinner at the University Club of members of our Society and of members of the Civil Engineers, in honor of our Past President, Mr. John R. Freeman and our President, Mr. M. L. Holman, together with Messrs. Charles L. Harrison, Allen Hazen and Frederic P. Stearns, who constitute the Commission to appraise the Denver Union Water Works.

ERICSSON MODELS

Objects of interest displayed in the Reception and Board rooms of the Society were the Ericsson Models, recently acquired from Mr. G. N. Robinson, Executor of the Ericsson estate. These have, until the present time, been on view at the Metropolitan Museum of Art, but are now to be permanently exhibited in the Engineering Societies on account of the belief that that is the logical depository for such objects. In this connection, it is natural to suggest that if any member knows of any books or objects of historic interest which may be presented to the Society, word to that effect will be gratefully received by the Secretary. We now have a fire proof building, vaults, and every facility for adequately exhibiting and caring for all such matters of scientific and historical interest.

GIFT TO THE LIBRARY BY HENRY R. TOWNE

Under the heading of "New Books" on another page will be found the volumes, over one hundred and fifty, which have just been given by Mr. Henry R. Towne, Past President of the Society and also of The Mechanical Engineers Library Association.

Many of these books were originally in the library of Mr. Towne's father, John H. Towne, which adds especial interest to these early works on engineering. This gift is indeed an inspiration to all interested in the Society's welfare, and we are sure we voice the wishes of the thoughtful friend of the Society who has placed these books in the library that his greatest satisfaction will be in finding them much used. They will be known as the Towne Collection.

GEAR CUTTER

The gear cutter shown herewith has been presented to the Society by Mr. A. D. Finley, Associate Member. It was made and used at the works of Russell, Birdsall and Ward, Port Chester, New York, in 1848. The information in regard to it comes from one of the old employees of the company who used to run the miller on which it was used. The cutter was formed on a lathe with the old style hand tool and the teeth were cut with a file.

GEAR CUTTER MADE IN 1848

The milling machine on which it was used was also made by the firm. It was invented by Mr. W. E. Ward, and run under his supervision. Most of the work on the machine was chipped with a chisel and finished with a file, as they did not have any planer or shaper for this class of work.

The machine was so arranged that bevel and miter gears were cut on it, with fairly good results. The worm wheel on the work spindle was cut by revolving a tap in a lathe and holding the disc

against it. This wheel contains 720 teeth, and was made in sections of brass. It is in good repair, and was used up to 1899 for milling nicking-saws, with excellent results.

INTERNATIONAL CONGRESS

An International Congress, dealing very largely with the scientific and mechanical end of the development of mechanical refrigeration, will be held in Paris, France, in June of this year.

It is desired that societies interested in mechanical refrigeration should be represented by delegates; a resolution was presented by Mr. G. T. Vorhees providing for the appointment of an official delegate to attend the Congress. The resolution was adopted, and at the suggestion of the Chair, the appointment of the delegate was referred to the Council.

A GIFT TO THE SOCIETY

During the Annual Meeting Mr. H. H. Suplee, Chairman of the Library Committee announced that he had received for the Society an interesting and valuable gift from its former President, Professor John E. Sweet. This was a fine old copper-plate impression of the certificate of membership in the Insurance Society of the Soho Manufactory of Boulton and Watt, at Birmingham.

The history of this engraving is as follows:

At the time of the death of James Watt, the room in his residence, Heathfield Hall, in which he did his private experimental work, was allowed to remain exactly as it had been left by him, and the subsequent owner of the house, Mr. George Tangye, of the well-known firm of engine builders of Birmingham, allowed this memorial of the great inventor to be visited by engineers and others, and doubtless many of the members of the Society have availed themselves of the privilege. In 1903 Mr. Tangye came across a package in this room, sealed with the seal of James Watt, and upon opening it he found three impressions of the certificate of membership above mentioned, and one of these impressions was sent to Professor Sweet by Mr. Tangye through the hands of Squire Potter and William Pimlott. With the copy there came also to Professor Sweet the pasteboard backing of the parcel, still having attached to it fragments of the seal of Watt. To this Mr. Tangye added a photograph of the interior of the room in which the package was found, this photograph showing clearly portions of the carving and duplicating machine upon which Watt was engaged at the time of his death in 1819; also an old copy of one of the rules of the insurance society.

An interesting feature of the old engraving is that in the background is a view of the original works of Boulton and Watt, at what is now known as Handsworth. This building was pulled down in 1863, and Professor Sweet had made a sketch of it at that time, completing the view by the appearance of the portion still standing. This drawing, published in Cassier's Magazine in March 1897, has its correctness fully confirmed by the contemporary picture of the building as it appears on the old engraving. These relics of Watt have been presented to The American Society of Mechanical Engineers by Professor Sweet and will be framed and placed among its increasing collection of documents relating to engineering history.

Mr. Suplee also presented to the Society an interesting document relating to the work of Robert Fulton. It is well known that at the time Napoleon was preparing his projected invasion of England, from 1802 to 1805, Fulton, then a resident of France, offered to him a plan for the steamboat as a means of conveying his troops across the channel, during calm weather, when the British sailing vessels would be powerless. For sometime the original record of this offer of Fulton's could not be found, but it is now known to be in the archives of the Conservatoire des Arts et Métiers in Paris, and, through the efforts of his friend M. Jacques Boyer, Mr. Suplee stated that he had succeeded in obtaining a photograph of it. This photograph includes a four-page letter in the handwriting of Fulton, describing fully his plans for steam navigation, together with a complete drawing of the steamboat, representing the machinery practically as it was subsequently employed on the "Clermont." This letter is addressed to the Commission to whom Fulton was referred by Napoleon, consisting of MM. Molard, Bandell, and Montgolfier, but their adverse report prevented the plan from being put into execution, otherwise it is possible that the fate of Europe might have been changed. It is interesting to note that Montgolfier, the inventor of the balloon, was a member of the commission that rejected Fulton's plan.

These documents are dated 4 Pluviose, year XI, in the French Republican Calendar, corresponding to January 25, 1803, thus antedating by about three and a half years the first trip of the "Clermont" on the Hudson.

These documents were received by the Society and placed in charge of the Library Committee.

INAUGURAL BANQUET OF THE ENGINEERS CLUB

The Inaugural Banquet of the Engineers Club was held at the new Club House, No. 32 West Fortieth Street, Monday evening, December 9, 1907.

Andrew Carnegie, Samuel L. Clemens (Mark Twain) and Thomas A. Edison were the guests of honor.

The banquet was presided over by T. Commerford Martin, President of the Club.

PRESIDENT MARTIN Seven months ago, with appropriate and dignified ceremony, after four years of preliminary planning and construction, the splendid building of the Engineering Societies on Thirty-ninth Street was dedicated to the service of mankind. To-day it shelters a score of engineering societies, and in it some 15 000 engineers find their home and headquarters, with a library, the finest of its kind in the world, and with potentialities of usefulness unequaled in their concentration and dynamic value. That was all rendered possible by the gift and generosity of one man—a man instinct with imagination, yet open at all times to the sympathetic prompting of kindred minds working along the same lines of devotion to the public welfare.

To have created another engineering center; to have erected one more engineering building; to have endowed another center of post-graduate technical study, would not have been in itself an achievement *hors de concours*. The unique thing, the touch of genius, the doing of something worth while that had never been done before, lay in the simultaneous recognition of the equal importance with the technical, of the social side of engineering. The same stroke of the pen, the same sententious prodigality that raised to the skies the noble front of the Engineering Building on Thirty-ninth Street, called into existence at the same time our own beautiful and comfortable Club House. It was all one idea; all one gift.

When your Board, as your representatives, requested upon the occasion of the seventieth birthday of our guest, that he would honor us by being with us that evening, he replied very properly and felicitously that that night he must spend at home in the

seclusion of his domestic life. We could not but agree with him, yet when we remembered his own happy phrase that he would "provide a home for us all," we felt that here he was just as much at home within these walls to whose very bricks we have nailed his portrait, as within his family circle.

The other day Edward Payson Weston walked, in his seventieth year, from Portland, Maine, to Chicago, Illinois. The destination would, perhaps, hardly seem to justify the effort.

One of the newspapers, commenting upon the achievement and upon the fact that there were two other septuagenarians, said, "John Pierpont Morgan and Andrew Carnegie may be healthy at seventy, but they could not do what Weston has done." That remains to be proven. As to John Pierpont Morgan, his job is not starting runs, but stopping them. As for our guest of the evening, he remarked on his birthday that he had spent the previous afternoon doing 18 holes in 70, on St. Andrews golf links, in company with a braw young college president of the city, whom he had held down to an equal score.

We, who stand within these walls to-night, through his generosity have realized hopes far beyond anything that we dared expect or anticipate. We share the feelings of our friend's opponent and antagonist as he endeavored to reconcile his diplomacy and his drives with his heart's desires.

Now. I shall ask you to drink to a toast, and shall give you a health—

Not to the greatest ironmaster of this age; not to the creator of a thousand and one libraries; not to the liberal endower of research and education; not to the rewarder of heroic self-sacrifice, but to our benefactor, our intimate and our associate, our comrade and our friend—Andrew Carnegie.

MR. ANDREW CARNEGIE It is most embarrassing for one to sit and hear his eloquent friend speak as he has been speaking of me. Still, he means well, and he does believe part—perhaps most of all he said.

I remember the occasion to which your president referred. It was a great step forward to make a home for the various engineering societies of this city, and I might say of this country—a great step forward. It was a great step forward when you made a Club House where you could meet—not to have revealed to you the abilities of your compeers, but their kind, friendly natures.

The longer I live the higher I value the personal equation. When you grow up with a lot of friends and become essential to each

friend's happiness, *there* is a union that will present the best results. All knowledge is contributory to every part of other knowledge; it is a great whole; knowledge is one great whole. Every one of you—I don't care in what department of engineering you are, gas, electricity, gasolene, steam or whatever miraculous power our friend, Mr. Edison, may next produce, you can all contribute to each other in your various departments. It is the greatest benefit to you gentlemen to come in contact with men in different departments of your business. It will make each of you more perfect in his own department, and I look upon this club as one of the most potent forces for producing splendid results of anything that has been heretofore undertaken.

I have been sitting here in conversation with my friends and have been more and more impressed with the thought that this is the age of the engineer; it *is* the age of the engineer.

I have been reading Kipling's latest production, it is an admirable one—"The Sons of Mary and Martha," and he closes by quoting from the Scriptures: "Cast thy burden on the Lord." The sons of Mary heard the word and did, and the Lord, he laid it on Martha's sons. He has laid it upon the engineers to do the work of this world in one of the greatest departments of all human effort. They are all interlaced, one coöperating with the other. Through the efforts of Mr. Edison, we have the phonograph; we now talk across the Atlantic ocean without wires; we tunnel under rivers, and are surrounded with such mysterious forces that I look upon such revelations to come within the next twenty years, as great as in the past decade, and it will be mainly through science and engineering.

Kipling has a beautiful thing in "M'Andrew's Hymn," he describes him coming through the snow and floes and blow with his ship.

"The bergs like kelpies overside that girn an' turn an' shift;
Whaur, girdin' like the Mills o' God, goes by the big South drift;
(Hail, snow an' ice that praise the Lord: I've met them at their work,
An' wished we had anither route or they anither kirk.)
Yon's strain, hard strain, o' head an' hand, for though Thy Power brings,
All skill to naught, Ye'll understand a man must think o' things."

Then he closes with this:

"Three weeks an' odd by any road ye steer—Fra Cape town east to Wellington,
—an' ye need an Engineer!"

The world needs the Engineer, and we may agree with M'Andrew, he serves the Lord well who attends to his duties.

I trust that in your friendly intercourse within this Club you will become such devotedly attached friends that when you reach maturity —I see you are all remarkably young looking—and in after life begin to exchange reminiscences, that you will be able to repeat with Hamlet:

"I think myself in nothing else so happy,
As in a soul remembering my dear friends."

PRESIDENT MARTIN In 1902, another famous engineering banquet was held in the Waldorf-Astoria, in honor of the eightieth birthday of one of our number, and of his distinguished career. Then the four National Engineering Societies founded a gold medal in his honor, a medal since conferred upon Lord Kelvin, George Westinghouse and Alexander Graham Bell—three fixed and shining stars in the great firmament of engineering and invention.

That night a lady guest of the hotel wandered into the banquet room, where the decorations were being made, and saw emblazoned upon the wall a statement that the guest of honor that night was eighty years old, and that he was going to speak. "What a shame," she said, "to be dragging an old man like that out of his bed."

Tonight, five years later, slightly grayer, somewhat more mellow and sweet of nature, that Engineer is with us again. Not dragged from his bed, but like some Harry Hotspur, or impetuous Prince Rupert, he has come to see me two or three days in advance, calling me up on the telephone this afternoon to come over here and rehearse "his piece" with him.

This is the Christmas season the time of all the year most touched with the sentiments of peace and love and good will, and while our thoughts turn to a green hillside far away in the Holy Land, let me, for one moment, also direct your thoughts to a swart and smutty hillside in the Lehigh Valley where his genius has called into being a great industry, and where Providence has, in the minds of American engineers, forever associated the sacred name of Bethlehem with the love, sweetness, the purity and charity of our dear good friend John Fritz.

MR. JOHN FRITZ I fully appreciate the honor you have conferred on me, and were I able to acquit myself with the credit due the occasion, it would be a source of great pleasure to me.

It is all very well until it comes to making a speech. In the first place, I didn't want to do it. Mr. Martin tried to make me believe it was the proper thing for me to do, and that was not all, it was a duty I owed to the Society, but I can't see it.

Had I been permitted to follow my own inclinations I should, as the authorized representative of The American Society of Mechanical Engineers, have taken our most worthy guest by the hand and presented to him the Certificate of Honorary Membership in the Society, congratulated him upon the honor thus conferred, and upon what he had done for the engineers, then taken my seat to listen to the speakers that are able to do honor to the occasion.

Had I been permitted to do so I would be happy, as a man feels happy in doing what he is conscious he can do well. Being one of the oldest members of the Society, and having taken a great interest in the subject that has brought us together this evening, some of our members thought it was not only fitting that I should say something on the early efforts to get the engineers in closer touch with each other, but it was a duty I owed the Society that I give some reason why I have taken so much interest in this subject.

There are many, but I shall mention only one; to enumerate them all would make a volume.

I shall refer to the Bessemer early days, when it was in the throes, but it is impossible for one wholly unacquainted with its early history, even in a measure, to realize the difficulties that were encountered; many of them were most dangerous to life, limb and property, and I know of no business that requires such an amount of diversified talent.

For this reason, I have selected it in order to show the importance of many-sided men. The difficulties were so numerous and so great that the captains in charge would visit each other to talk over their troubles and they greatly profited by this course. In fact, it was a great school. In a short time it raised the process from a doubtful success to the most marvelous manufacturing business of the world. This so impressed my mind that I talked to Mr. Holley about a closer association of the engineering societies, and found him fully in accord with my views. He then talked with Mr. Eckley B. Coxe, and Mr. Samuel Thomas, and they both fully agreed with Mr. Holley and me. Then the question came up as to how it could be brought about. I think it was Mr. Holley who suggested that we get up some plan that would get the engineering societies in closer touch with each other.

During the latter part of Mr. Holley's life he would spend three or four days at a time with me, and Mr. Coxe was a frequent visitor. At times I would arrange to have them both at the same time. As they were both well educated and I practical, we all greatly profited by our coming together, and we all seemed happy when together, so it

was like a love feast. Could they have lived to have been with us on this occasion, how happy they would have been and it would have added a thousand per cent to my happiness.

How to get engineers together, this was the problem in or about 1880. Mr. Holley died in 1882. Since that time Mr. Coxe and Mr. Thomas have died. Both were able and noble men. After the death of Mr. Holley, the subject was dropped, but not entirely forgotten. Now, after twenty-four years, through the munificence of our most worthy guest, we find ourselves in possession of the two finest buildings in the world for the intended purpose.

The engineer is the most important personage upon the world's stage, whether the drama be peace or war! Mr. Carnegie, in erecting these magnificent buildings and dedicating them to this use and purpose, has recognized the work and worth of the engineer and placed him in a position most justly his.

The kindly feelings existing between the engineering societies promise well for the hope that through the influence of the engineers nations may be drawn into closer bonds, and by our united efforts all flags entwined in an everlasting emblem of peace.

May this be the glory of the engineer and the crowning glory of the twentieth century.

PRESIDENT MARTIN Mr. Fritz has requested me to present to our guest of the evening this engrossed document, which is a Certificate of the Honorary Membership of Andrew Carnegie in The American Society of Mechanical Engineers, given upon the proposition in accordance with its Constitution that Andrew Carnegie is the greatest ironmaster that the world has ever known, signed by:

THOMAS A. EDISON,
ALEX. C. HUMPHREYS,
E. R. ARCHER,
JOHN A. BRASHEAR,
CHARLES H. MORGAN,
JOHN FRITZ,
W. R. WARNER,
JOHN E. SWEET,
THOS FITCH ROWLAND,
S. T. WELLMAN,
CHARLES WALLACE HUNT,
CHARLES H. HASWELL.

MR. CARNEGIE I have received many compliments, many honors during my life, far beyond my deserts, but this I can truly say, that the honor you have done to me tonight in making me an Honorary Member of The American Society of Mechanical Engineers, goes to my heart and causes it to throb.

I owe everything to the engineer, as you know, Mr. Fritz. I have

been brought up with them; I never could be much of an engineer myself, but knew a good engineer when I found him.

I assure you that this will go down to my descendants and be held by them in esteem as long as anything connected with my name may remain within the remembrance of man.

PRESIDENT MARTIN There are other birthday celebrations in store for John Fritz, so let's give him a rest now.

Date 1853; "I started on my travels to see the world. The world was New York City, and there was a little World's Fair there. It had just been opened where the great Reservoir afterward was, and where the sumptuous Public Library is now being built—Fifth Avenue and Forty-second Street. I arrived in New York with two or three dollars in pocket change and a $10 bank bill concealed in the lining of my coat."

Thus has a great American moralist modestly suggested the parallel between himself of arriving in New York and Benjamin Franklin landing in Philadelphia. The world is still New York, and we are still stitching $10 bills in the linings of our coats.

Since that World's Fair, New York City has expanded into Vanity Fair, far beyond the noble vision of the immortal John Bunyan, but amid all the marvelous changes and transmutations and transformations of this metropolitanism of ours none has been more remarkable than that which has occurred on this very spot of which you have just had the recital in this autobiographical passage, "To be published only after my death."

What greater and more beautiful change could there have been than that which has seen the grim old granite water reservoir here undergo its transformation into that beautiful and magnificent marble palace, a reservoir which once satisfied the mere physical thirst of a young and growing city, but which today, under its new régime and auspices will administer to the slaking of the thirst, intellectual, spiritual and moral of five millions of men and women in this great metropolis of the New World.

Ever since that wayward youth in truant frolic wandered through these green fields and that World's Fair a spirit of humor and of joke has hovered over the spot so that when the City Fathers named it Bryant Park, and then installed within it a bust of Washington Irving and having paid that distinguished compliment to the literary ancestor of our next speaker, they capped the climax by putting into position a full length statue of a distinguished physician, noted for the success of his surgical operations.

Anon, the park behind me will be ornamented alike with statuary and with fountains.

The Poet Tennyson speaks of "Heart affluence from founts that ne'er run dry." For two generations such a fount has been throwing up its sparkling waters with ripple and splash and mellow burst of bubble in the laughing air, and welling up joyously, throwing its rainbow hues on the common things of life and making everything sweeter and purer and better and more beautiful by its kind and cleansing humor.

That well-spring will be perennial within that reservoir when its marble gates are thrown open to the thronging multitudes, but tonight we can anticipate, we favored mortals, and like Moses, split the white rock of Twain.

MR. CLEMENS I did arrive fifty or sixty years ago in this friendless desert, which he has described from this manuscript which seem. to have got into publication before I am dead—unless I am dead nows

I arrived here with $3 in my pocket and $10 sewed in the lining of my coat, but I have prospered since. Now I have got plenty of money, with a disposition to squander it. Fortunately I cannot do it because one of these trust companies is taking care of it.

The Chairman has paid me some compliments; I was expecting them. They are very gratifying to me.

Now, I am here probably for the only time that I shall appear after night-fall this winter in New York City, and I feel that I have not come here amiss. I have come here on an errand of value. I have been chief guest myself at banquets and I know what this one is feeling like now. Our guest confessed in the opening of his remarks that he was embarrassed by the compliments which were falling to his share. Now, that is perfectly true. What can be more embarrassing than is the case with a chief guest at a banquet when he gets compliments and compliments only? It is necessarily embarrassing because he knows in the inside of him, that if you looked at the other side of his character, you would find something that would bear censure.

Now to hear all this talk—and there will be more of it—and to look at Mr. Carnegie's face, all scintillating with fictitious innocence, you would think the man never committed a crime in his life. Oh, no! But look at his pestiferous simplified spelling. Why, you cannot imagine the calamity that has been on the two sides of the ocean. Torquemada was nothing to Mr. Carnegie. He shed a little blood during the Spanish Inquisition, but Mr. Carnegie's simplified spelling

has brought disaster upon the whole human race. It is merely a crime without any intention to it. He meant to do well; he did the best he could and he has got it all now so nobody can spell anything.

He attacked orthography at the wrong end; he attacked the symptoms and not the disease. The real disease is in our alphabet; there is not a vowel in it with a fixed and determined and definite meaning for its existence; not a single definite value, and the same with the consonants. He called your attention to that himself, with the h's distributed all around with no sound to any of them. What do you want with "h" in "Gherkin"? What do you want with any of those h's that are silent; there are so many of them that are silent. I admire the English because they do not care anything about them; they drop them everywhere.

And there are the consonants: That "p" in pneumonia and pneumatics, what is it for? And the three consonants in "Phthisis" that are valueless and have no business there. Mr. Carnegie himself has suggested they ought to be thrown overboard along with the u-g-h's. Adequate reform would furnish us with consonants with a definite function to perform, the same as vowels; furnish us vowels with a definite function to perform and restricted to that. With an alphabet like that one would not have to learn to spell at all. One would only need to learn that alphabet and, once learned, could spell any word in the world without any trouble. In fact, you could, after studying that reformed alphabet two or three hours—after mastering that alphabet in that little brief time—you could spell any word in the unabridged dictionary and spell all of them accurately and instantaneously with your eyes shut.

By reason of the present alphabet there is not a man in this house that does not have to avoid or throw to one side about fifteen hundred words every day in his correspondence because he does not know how to spell them; and that is a pitiful thing; an alphabet to treat you like that, an alphabet that puts you in a position where you cannot spell those 1500 words, that that man spent weeks and weeks, and months and months and years and years of his life time in learning how to spell. It is like a man trying to learn to dance with wooden legs. It is all wrong. Now, there is not a man in this house that can spell "Pterodactyl" right off the bat, I mean, except perhaps it is the prisoner at the bar, and goodness knows what he would make out of it. I should just like to hear Mr. Carnegie spell "Pterodactyl;" not in public; not here; it is too close to Sunday when all extravagent histrionic exhibitions have been abolished by a law as old as the Middle

Ages. But I should like to hear him spell that word in private, and when he got through spelling "Pterodactyl" you would not know whether it was a reptile or a bird, and the chances are that he would give it a tusk and a trunk and make it lay eggs.

If we had a graduated system of accents distributed among those vowels, giving to each vowel its own special, sole and unalterable value, its own value, its one value, so that every shade of that vowel would be represented and recognized in that accent accompanying it, there is not a word that could be uttered by any tongue on earth that we could not spell instantly without reflection, and with absolute accuracy.

That you know would be real simplifying; that would be competent simplifying; that would be adequate simplifying, not inadequate and incompetent simplifying by removing the hair and bunching the words and scrubbing them off, and lancing the carbuncles, and eradicating the cancers; leaving the whole thing substantially what it was before it became bald and sightless.

If I asked you what "B-o-w" spells, you cannot tell me until you find out which "B-o-w" I am talking about. And it is the same with "R-o-w," "L-e-a-d" and "R-e-a-d" and "B-o-r-e," and all that whole family of bastard words born out of lawful wedlock and that do not know their own origin.

I would like to appoint Mr. Carnegie to take hold of that alphabet and let simplified spelling alone. Reform the alphabet and we will all pray for him, if he dares to take the risk.

Now, I hope I have soothed him down and made him more comfortable than he would be if he got nothing but compliments and compliments; and I wish to say to him that his simplified spelling is well enough, but like charity, you can carry it too far.

PRESIDENT MARTIN At an earlier stage of the evening, Dr. Clemens had asked we what I considered the most distinguished element in regard to engineers that was one in common with them, and I said that perhaps that which did distinguish them universally and which they had in common, was their bad spelling. You have the clue to his speech of the evening and the explanation why Mr. Carnegie, in picking his engineers, found that it was necessary to take one step further in their education.

The daily newspapers during the past month have been laying emphasis upon the remarkable phenomenon of the ebbing tide of travel and of emigration eastward to Europe. Each steamer, as she has sailed eastward, has carried hundreds and thousands of returning

exiles of the dispirited foreigner, the despondent unemployed and discouraged laborer; but scan those lists as closely as you may of the departing victims of the financial and industrial debacle of the past few weeks, look at the growing multitudes on the docks of West Street and of Hoboken and you will not see a Scotch name nor be confronted by a Scotch face nor will you hear the Scottish accent. The excelling virtue and quality of a race permanently distinguished for endurance and steadiness of purpose is manifested now more than at any other time and hope springs eternal for the future of a country which the Scot cannot be induced or driven to desert for his own.

A volume was published recently by an Englishman, entitled "The Unspeakable Scot." It is needless to say that it has been placed upon the Index Expurgatorius of the Library of the Engineers' Club by Chairman Dwight. In fact so largely are we Scotch in our make-up that there might well be a clause in our Constitution limiting members, to men of Scottish birth or descent.

In fact, as I look around me, and remember that three past presidents, two of them Charles Macdonald, and John Thomson, are both of the Scottish persuasion, and as for Mr. Fletcher, he is a marine engineer, and he might as well be one of them for they are all Scotch anyhow.

Unspeakable as the Scots may be, when I call on my friend John Foord, our fellow member of the Burns Society, you will agree with me that they are not speechless, and I shall therefore ask Mr. Foord with unaccustomed brevity and unwonted modesty, to enlarge upon the glories and virtues of the Scot in America.

JOHN FOORD I share with your President the satisfaction he has expressed that the life-blood of this country has not been drained by the departing Scot.

As a correspondent of the "Illustrated London News" said at Shanghai, when he landed there after a trip around the world, and they asked what was the most remarkable part of his experiences; how did he get so far in Central Asia, and so on; how he contrived to keep body and soul together on these pathless steppes, he said: "That was nothing, hard boiled eggs and other indigestible things were luxuries to us, but I will tell you what struck me most was when we went to Canada and found there the men in public office were mostly Scotchmen; and we went to India and found there the men who were administering the British Empire, mostly Scotchmen; and when I came to Shanghai and I find your prominent merchants mostly Scotchmen. 'Eh, mon, we are a braw race.'"

Now, in speaking of the Scot in America, it is usual to ransack the records of history to find out the individual Scots that have shown ability in statesmanship or finance or science or industrial activity. But, really, gentlemen, this record has been the record of all Scots in all of those capacities. I venture to say that scores of recorded Scotchmen have done less for American history and have done less for American character and have less influence in American life than the unrecorded influence of thousands of Scotchmen who have never got their names in the Biographical Dictionary.

The President has referred to the fact that there is quite an affiliation of Scots in the Society, but more than that, gentlemen, it must have occurred to you as remarkable that there are a large number of Americans who find some strain of Scottish blood in their ancestry, and who point to that with pride. I do not know that the individual Scotchman is a person that perhaps is desirable to claim kinship with. I know there are people who have more personal geniality and are more remarkable for sweetness of temper, but the race, as a race is an imaginative one, and it has dominated the imagination of the world. Side by side with his practical hard qualities there always is a poetic quality that reaches out to things not seen, and that is the thing that has captivated the imagination of the world.

There is in this company, gentlemen, a trio of Scotchmen who well illustrate the point. I see before me Admiral Melville—with the head of a poet; the mien of an emperor; with a talent for discourse that has held some of you here from eight o'clock at night until twelve, and you wanted him to go on and on; never tired of the stories he had to tell.

I see before me another Scotchman who has distinguished himself in various practical ways in engineering—our friend John Reid.

Is Mr. John Reid known to you by his practical efforts? Not at all; he is known to you as the foremost exponent of Scottish song that is known to you today. He is not known to you on account of his vocation, but for the thing he calls his avocation.

Our former President, Mr. John Thomson, has the Scotch air all over him as if he landed but yesterday; an absolutely Celtic type; John Thomson is a very practical man in his life in all that applies to mechanical engineering and correlated things, but John Thomson has more pride in composing a few verses to send to somebody else than he has in all the mechanical contrivances. Now, there is the Scot, gentlemen. The Scot in America is a most extraordinary compound of the practical instinct with the poetical instinct, and with a contempt for all shams.

With the permission of our friend and our guest of the evening, I will refer to him as the typical Scot, with all those things that I speak of, with this fine instinct and fine sentiment for those Scotch things, and yet, with all his vocation somehow seems subordinate to his avocation.

Now, it is an Engineers' Club and an Engineering building; now a Peace Palace; now a Carnegie Institute in Washington—and I mention not the libraries and all those things that are public property—for I am thinking of the things that require some imagination and our friend and fellow member and benefactor here, Mr. Andrew Carnegie, has displayed the Scottish instinct and the Scottish imagination which differentiates the race, I take it, from every other race.

The Scot in America has performed a useful function in the association of the practical; in the association of the actual with some pursuit of the ideal. The ideals that Mr. Andrew Carnegie has pursued and put in evidence will probably take time to show how great they were and are. I do not think this generation probably appreciates how great they are, but time, which has a way of adjusting things, will show that they are greater than even he or we imagine. It has already proved some thing better, as I look upon it from the calm standpoint of a member of this club, inasmuch as it has stirred us to renewed endeavor and to the necessity of living up to the benefactions we have received and has imposed upon us certain obligations which we did not foresee.

That is part of the idea of beneficence; not to disarm the activated, not to disarm or to blunt the strength of the people who are the beneficiaries, but to nerve them to new effort. You know what slight new effort you have been compelled to give here, but you are the heirs of a very large inheritance and you are only beginning to understand how big that inheritance is by the payment of some more annual dues.

I am not at all sure there is not a parallel in that; but Mr. Carnegie's beneficence has been uniformly—as nearly as I have been able to get at it—coördinate to the ability of the persons who have been benefited by it to make an effort themselves. You all know how difficult it is to do good without somehow blunting the strength or elasticity of the individual or organization that it is the recipient of your benefaction. Now, Mr. Carnegie must know a great deal more about that than any of us can tell him, and has probably carefully and thoughtfully coördinated his benefits to the people who are able to meet their part of the obligation and carry it on to new fields of endeavor. That, you will pardon me for saying it, is typically Scotch; something that

belongs to the race, because the character of the race was made in long generations of toil and struggle and they are never at all averse to condemning other people to the same discipline.

PRESIDENT MARTIN In the beautiful and appropriate menu of this evening, bound in the Carnegie plaid, are pictures of the first Club House in Twenty-ninth street, and our next Club House on Fifth Avenue, and now of our present Club House. Such pictures bring back to us the most tender of traditions and memories. And yet, so recent is it all that we have with us this evening in the presence of Mr. Henry R. Towne, a member who presided over the meeting at which this body was organized. Thus through all our growth we have enjoyed the coöperation, the work, and devotion of many men, some of whom are no longer with us, but whose deeds and whose faith, whose zeal and whose loyalty have been to those of us who came after and still remain, a constant inspiration. It is a singular fact, as already alluded to by my friend, Mr. Foord, that, interwoven and blended in the fabric of this Club is the personality of so many men who have had to do with steam engineering afloat and with shipbuilding, and tonight, as we think of that splendid fleet of battleships in a column three miles long, starting out for its destination on the Pacific, fourteen thousand miles away, we can glory in the fact that so many of our members and our fellows have contributed to that magnificent result; such men as are exemplified and typified in the man who laid the foundation of it all, the one man of all others who made it possible—Rear-Admiral George W. Melville, our fellow member!

Gentlemen, you can understand, therefore, that when this Club confronted the proposition of a new Club House, it naturally selected a shipbuilder as the Chairman of its Building Committee. There was but one injunction laid upon him, that injunction which you will find in Longfellow's beautiful poem, namely, "To build a ship that was worthy of him and of us." And, as a member of the Building Committee who has served for four years past assisting that Chairman in his labors, having attended hundreds of meetings, having assisted in innumerable consultations with our brilliant architects, Messrs. Whitfield and King, having battles royal with contractors and parleying with the enemy at the gates in the shape of rotten, corrupt and blackmailing labor leaders, a discredit to the very cause of union labor—I stand up tonight to testify to the zeal and loyalty and fidelity of my esteemed predecessor, the Chairman of that Building Committee, the man whom his friends affectionately call "Bill Fletcher."

WILLIAM H. FLETCHER I had prepared a speech for tonight. I thought when I became an ex-president that I might be permitted on this occasion to sit down with my friend John Thomson, one of the boys, and have a good time, but our Chairman upset that, and he told me I was to be at the guest table and was expected to make a speech. I carefully prepared one, but since I sat here, surrounded by so much talent, something happened to it. I think it shared the same fate as the Scotchman's baggage when he was asked what had become of it, he said, "the cork came out."

I did not know how to get out of my difficulty, but my good friend, the Rev. Wilton Merle Smith, told me a story of Mark Twain when he was first introduced to General Grant, he said to General Grant —President Grant, as he was then—"Mr. President, I am embarrassed; how do you feel?" That is my feeling tonight and so, with your kind permission, I trust you will bear with me while I say a few words in regard to the Engineers' Club, because that is a subject I know most about.

It is singularly appropriate tonight at this Inaugural Dinner and formal opening of the new Club House. I never knew until tonight why I was chosen to fill the position, but now I see they needed a nautical man because the committee was at sea at once.

The Building Committee has finished its labors, and at the next meeting of the Board will present its final report and ask to be discharged.

This is the report that we will make in regard to the new building: The property cost us $265 000. The cost of the house is $545 597.80 of which we received from Mr. Carnegie's gift the sum of $450 000. The cost of furnishing the Club House was, $57 285.31, making the total cost of the building and land, $867 883.11.

The total indebtedness is as follows: Mortgage to the Bowery Savings Bank of $110 000 and bonds sold to members $200 000, making a total of $310 000, leaving an equity of $557 883.11. I think that is rather a healthy showing for a club.

I want to say tonight, and it is only fair that I should say it to all the members of the club, that the Building Committee has given their time and experience unsparingly. We have held many meetings, as Mr. Martin has said. Although engaged in important work they have left that work to come and fight with contractors over some trivial thing which their time more than paid for, but they have given their time and attention to the building, particularly Mr. Weed and Mr. White. In the last six months they have devoted almost their entire time to it, in connection with the architects and going over

various details in trying to hurry the work, and the Engineers' Club is greatly indebted to them. But, tonight I think we should not forget, we who are in the limelight and those of us receiving your thanks and having nice things said to us, that after all we are but a small part in the evolution of the Engineers' Club. We must not forget that this Club House which we are now enjoying has been worked for and thought about by many of our predecessors—Messrs. Stanford, Thompson and Kafer. To no one man in the Club is the Club indebted more for this building, for our removing from Twenty-ninth street to Fifth Avenue and from Fifth Avenue here, than John C. Kafer.

While it is not my desire to inject anything sad on an occasion of this kind, I think it is only fair to you, and I think it is only fair that Mr. Carnegie should know that the last act of John C. Kafer was the performance of his duty as Treasurer of the Engineering Society. I was called to his home on account of his illness and when I reached there I saw at once that his days were over. He asked his sister to bring him some papers. The papers consisted of a small book in which he had kept for his personal use an account of all the receipts and expenditures on account of these buildings. The other two papers were checks or drafts, one made payable to the contractor of the Engineering building and the other one for this building. They were unsigned. We propped him up in bed and he took pen and ink and executed those two papers, and that was the last act of John C. Kafer.

With the permission of our President, I will ask you all to fill your glasses, and rising, drink a silent toast to the memory of John Stanford, Addison C. Rand, Thomas Loring, John Thomson and John C. Kafer.

President Martin Gentlemen, the sentiment which underlaid and inspired the brief but eloquent remarks of Mr. Fletcher was this: If you would find his monument, look around you. But tonight one other obligation lies upon us and that is to recognize that upon which our guest of the evening has already complimented me as your presiding officer, namely the admirable quality, the excellent service, the exquisite finish and the comfort of every detail of this first banquet in our new home, and you will permit me to ascribe the credit for the brilliant occasion and for the splendid repast which we have enjoyed to our Chairman of the House Committee—Charley Wales!

You all know the functions and the privileges of the Chairman of the House Committee of a Club and I can assure you that in the execution and discharge of his duties, Mr. Wales has borne insult and con-

tumely with a serenity positively beyond belief. When I complimented him upon his success in doing so, he said to me that hereafter his name ought to be "Welts and Wales."

Now, the Chairman of the Building Committee wishes me to recognize and announce the following gifts to the Club that have helped us make it a success and the convenient and comfortable quarters in which we find ourselves.

Babcock & Wilcox Company, two boilers

Allis-Chalmers Company, two 50 kilowatt generators and engines complete.

General Electric Company, one 75 kilowatt generator, driven by Curtis turbine.

F. E. Idell and E. Cochrane Company, Feed water heater and steam separators.

Consolidated Safety Valve Company, Safety valves for boilers.

Hancock Inspirator Company, Boiler check and club valves.

Hayden & Derby Manufacturing Company, two Metropolitan injectors.

The Ashcroft Manufacturing Company, All the steam gages, glass mounted on marble switch-board.

James Beggs and Company, Full set of McClave shaking grates for boilers.

Manning, Maxwell and Moore, One Tabor engine indicator.

Van Dyke, Churchill and Company, Duplex oil filters.

Charles Corey and Son, Brass railings.

I think, gentlemen, that these excellent, substantial and generous gifts should be inscribed on some tablet in the power-plant and remain there as evidence of our gratitude for their generosity.

ANNUAL REPORT OF THE COUNCIL 1907

The Council begs to call attention of the Society to the detailed reports of the several standing committees as best giving the work and progress of the Society during the past year. In these reports is shown that we have moved the headquarters to the new building of the Engineering Societies, including the library, without loss or damage to a single volume. The property at 12 West 31 Street has been sold at an increase of $37 000 over the purchase price.

In the report of the Land and Building Fund Committee will be shown the details of the payments on the present property. Not all of the money available from the sale of the property at Thirty-first Street was applied to the reduction of the obligations for the new headquarters, as a portion of this was required to rehabilitate the funds of the Society, Life Membership Reserve, Library Development and Weeks' Legacy, these funds having been previously invested in the obligations of the Society in the two properties. However $63 000 was immediately turned over to the Treasurer of the United Engineering Society, upon permission of the Supreme Court, through which the application for the merger of The Mechanical Engineers' Library Association with The American Society of Mechanical Engineers had been sought and granted.

An account of the dedicatory exercises have already appeared in the Proceedings, but will again be published by the Dedication Committee in a separate volume, uniform with the Transactions.

The monthly meetings of the year have been: January, Mr. Frederick P. Fish on "The Ethics of Trade Secrets;" February, Prof. Charles M. Allen, "Gasolene;" March, Mr. J. W. Lieb, Jr., "Vesuvius and the Mechanic Arts of Pompeii."

The Spring Meeting of the Society in Indianapolis was very successful and well attended and treated of symposiums on Superheated Steam, Automobiles, and various separate discussions on steel tubes, pumping engines, etc.

During the year the Council and Society have elected to Honorary Membership, Mr. Andrew Carnegie, donor of our new building. Honorary Vice-Presidents appointed to represent the Society during

the year have been as follows: at the convention of the National Fire Protection Association, Mr. John R. Freeman and Prof. Ira H. Woolson; Centennial celebration of the founding of the University of Tennesee, Mr. Newell Sanders, Prof. Chas. S. Brown and Mr. F. R. Jones; at the unveiling of bronze tablets in the Hall of Fame, New York University, Mr. Jarvis B. Edson, Mr. George R. Henderson, Mr. Benjamin F. Isherwood, Honorary Member of the Society, and Mr. Henry Harrison Suplee; at the Fiftieth Anniversary of the Michigan Agricultural College, Prof. M. E. Cooley, Alex. Dow, and Mr. F. E. Kirby; for the Hudson-Fulton Celebration, the President of the Society in office, and Mr. Fred. W. Taylor.

A new Junior badge has been approved by the Council, of the same design and form as the member's badge but enameled in crimson instead of blue. The reason for the change was that the old form of Junior badge was unlike the recognized emblem of the Society and therefore was not satisfactory. The new badge successfully meets this criticism.

Mrs. George H. Corliss and Miss Corliss presented to the Society the portrait of Mr. George H. Corliss, on the evening of dedication week, before a distinguished audience which had gathered to listen to the address of Brigadier General William Crozier. On Founders Day, a gold medal was presented to Dr. Frederick Remsen Hutton, in token of appreciation of his twenty-four years of service to the Society as its Secretary.

The Secretary would report for record the following deaths during the year, Messrs. C. T. Bayless, J. A. Brady, Fred Brotherhood, M. J. Daly, Wallace C. Johnson, Carlton W. Nason, Peter W. Luders, J. J. O'Brien, Vernon H. Rood, James Rowan, Geo. F. Stillman, W. D. Stivers, W. C. Turner, A. V. Abbott, F. Ramsey Allen, Hobart Canfield, Sir Edward J. Reed, Honorary Member, Admiral Chas. H. Loring, Past President of the Society, P. E. LeFevre, Geo. H. Evans, Jas. B. Cahoon, Norman C. Stiles, Herman Unzicker, Genl. Eugene Griffin, Sir Benjamin Baker and Chas. H. Haswell, Honorary Members, W. L. Simpson, L. K. Stearbs. A. F. Hall, C. J. Hillard, E. F. Gavagan, Peter H. Been, George Rowland, F. H. Williams, H. C. Moyer and E. W. Johnson.

Resignations during the year have been, R. P. Thatcher, Geo. H. Lilley, W. C. Temple, Clifford R. Harris, James M. Merton, Edw. F. Tolman, L. B. Melville, B. H. Dillon, James Atkins, Cris C. Wais, Taylor Gleaves, W. P. Heineken, A. E. Childs, S. H. Harrison, A. C. Christensen, E. F. W. Gaskin, W. S. McKinney, C. H. Hurd, Theo. F. Scheffler, R. Deane Brooks, J. B. Pitchford, Storm Bull, B. J. F. Bain

H. C. Moran, C. R. Diebold, Wm. Goodman, F. S. Greene, Jno. Clark Finney.

The Reports of Tellers on candidates for membership form part of the published records of these minutes.

OBITUARIES

THOMAS HILTON WILLIAMS

Thomas Hilton Williams, President of the A. A. Griffing Iron Co., Jersey City, N. J., died Saturday, October 19, 1907. Mr. Williams was born February 14, 1848, at Springfield, Mass., and early in life removed to Jersey City, N. J., where he subsequently became identified with the iron and brass metal industries. He graduated from Packard's Business College of New York and after a short experience in the banking business became a partner in the E. A. Williams and Son Brass and Bell Foundry of Jersey City. At the time of his death he was president of E. A. Williams and Son, Incorporated. Mr. Williams was perhaps best known through his long association with the A. A. Griffing Iron Company, makers of "Bundy" Radiators. He became an officer in that company at a time when cast iron was first used in radiators for steam and hot water heating.

He was a member of The Engineer's Club, the Lawyers' Club of New York, the American Geographical Society of Washington, D. C., and the Carteret Club of Jersey City, N. J.

HERBERT CLIFTON MOYER

Herbert Clifton Moyer was born in Danville, Pa., 1873. He graduated from the High School, and at a very early age constructed a miniature steam engine whose novel features attracted public attention. After graduating he entered the employ of the Enterprise Foundry and Machine Works where he served an apprenticeship, afterward entering the drafting rooms of the mechanical department of the Mahoning Roller Mills Company. He was next employed at the Mount Carmel Iron Works, the South Sharon Steel Company, and the Lukens Iron & Steel Company at Coatesville, Pa., retaining the latter position until his death, November 8, 1907.

WILLIAM SAMUEL LOVE

William Samuel Love was born in St. Louis, Mo., May 20, 1867. He received his early education at Smith Academy and the Manual Training School of St. Louis, graduating from the latter institution with the class of 1883. For a year he was engaged in railroad survey work through Texas, entering Washington University in St. Louis in 1884 and graduating from the mechanical engineering course with the degree of B.S., with the class of 1888.

His practical experience was obtained during his college course in the shops of the St. Louis Bridge and Terminal Railway Company in 1885 and 1886, and in the drawing room of the same company in 1888. He was for a year assistant engineer for the St. Louis Tie Preserving Company, and for three years was Secretary of the Pond Engine Company of St. Louis.

In 1892 he opened an office in Chicago, Ill., as mechanical engineer and agent for various steam engines, boilers, heaters, etc. In 1895 he took charge of the Chicago office of the Abendroth and Root Manufacturing Company of New York and assumed charge of the Chicago office of the Wheeler Condenser and Engineering Company in 1899. He remained in that position until January 1907, at which time he came to New York as general sales manager of that company, which position he held at the time of his death.

Mr. Love was a member of the Western Society of Engineers, Engineers Club of New York, Union League Club of Chicago and the Loyal Legion.

He was deeply interested in the development of surface and jet condensers, and during the last ten years of his life, was very instrumental in perfecting condensers of large capacity.

Mr. Love died December 11, 1907.

NEW BOOKS.

CARBURETING AND COMBUSTION IN ALCOHOL ENGINES. By Ernest Sorel; Translated from the French by Sherman M. Woodward and John Preston. *John Wiley & Sons, New York. 1907.* Cloth, large 12mo, vi, 269 pp., 26 figures and 5 full-page plates. $3.00 (12/6 net).

Contents by chapter headings: Translator's Introduction; General and Historical Facts; Conditions Affecting Combustion of Gaseous Mixtures; Phenomena of Combustion of Gaseous Mixtures; Actual Combustion in Engines; Carbureting; Temperature of Vaporization; Investigations of Carburetors; Effect of Temperatures Below the Temperature of Combustion; Instantaneous Action of Temperatures Relatively Moderate upon Alcohol Vapors and Their Derivatives; The Slow Action of Temperatures Relatively Low on the Vapors of the Alcohols or their Derivatives; Simultaneous Action of Heat and Oxygen; Action of Metals in the Absence of Free Oxygen; Summary of the Chemical Studies of Industrial Alcohol.

INTEGRATION. By Trigonometric and Imaginary Substitution. By Charles O. Gunther, Asst. Prof. Mathematics and Mechanics, Stevens Inst. of Tech. With an Introduction by J. Burkitt Webb, Prof. of Mathematics and Mechanics, Stevens Inst. of Tech. *D. Van Nostrand Company, New York. 1907.* Cloth 12mo, 76 pp. Illustrated. Price $1.25.

Contents by chapter headings: Introduction; Trigonometric Differentials, Trigonometric Formulae and Differentials; Rationalization by Trigonometric Substitution, Change of Form of Radical, Binomial Differentials, etc.

AMERICAN INSTITUTE ELECTRICAL ENGINEERS. *Proceedings. Vol. 26. No. 11. November 1907.*

AMERICAN INSTITUTE MINING ENGINEERS. *Bi-Monthly Bulletin. No. 18. November 1907.*

AMERICAN WATER WORKS ASSOCIATION. *Proceedings. 27th Annual Convention. Toronto, Canada, June 17–21, 1907.*

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MASTER CAR BUILDERS' ASSOCIATION. *Proceedings. Vol. 41. 1907. Forty-first Annual Convention. Chicago. 1907.*

NEW YORK STATE MUSEUM. Memoir 10. Devonic Fishes of New York. By C. R. Eastman. *New York State Education Department, Albany. 1907.* Cloth 4to, 193 pp. 15 plates.

NEW YORK STATE EDUCATION DEPARTMENT. *Third Annual Report for School Year ending July 31st, 1906. Albany, 1907.* Cloth 8vo, 657 pp.

NEW YORK STATE LIBRARY. *88th Annual Reports including Home Education, and the Library School. 2 Vol. Albany, 1905.* Cloth 8vo.

NEW YORK RAILROAD CLUB. *Proceedings. Vol. 17. No. 9. November 1907.*

NEW ENGLAND WATER WORKS ASSOCIATION. *Journal. Vol. 21. No. 3. September 1907.*

ROYAL SOCIETY OF NEW SOUTH WALES. *Journal and Proceedings. Vol. 40. 1906.*

SMITHSONIAN INSTITUTION. *Annual Report of the Board of Regents for year ending June 30th, 1906.* Cloth 8vo 533 p.

SOCIÉTÉ INDUSTRIELLE DE MULHOUSE. *Bulletin. August 1907.*

SYDNEY UNIVERSITY ENGINEERING SOCIETY. *Journal and Abstract of Proceedings for Session of 1906–1907. New South Wales.*

WESTERN AUSTRALIA GEOLOGICAL SURVEY. *Bulletin 6. 1902. Bulletins 20–26. 1906.*

"L'EVOLUTION DES FORCES." Lettre de M. le Professeur émerite V. Dwelshauvers–Déry (Honorary Member of The American Society of Mechanical Engineers), à Messieurs les éléves de l'École des Mines de Liége au sujet de l'ouvrage de M. Gustave le Bon. *Liege, 1907.*

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STAFFORDSHIRE IRON AND STEEL INSTITUTE. *Proceedings. Vol. 21. Session 1905–1906. 1907.*

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INSTITUTION OF CIVIL ENGINEERS. *Minutes of Proceedings. Vol. 169. Part 3. 1906–1907. London.* Cloth 8vo.

NEW EXCHANGES

THE RAILWAY GAZETTE. A Journal of Transportation, Engineering, Docks, Harbours, Contracts, and Railway News. *Published Weekly at Queen Anne's Chambers. London, England.* Size 9½ by 13 in. 6d.

TOWNE COLLECTION

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HINTS ON BUILDING

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

01 Active man to invest and take responsible position in gas power company now being organized. The company possesses valuable patents that have recently been demonstrated to be a complete success.

MEN AVAILABLE

1 Junior member; graduate Worcester Polytechnic, five years successful experience as erecting engineer, designer, engineering salesman and branch office manager with large concern manufacturing general line of heating and power machinery, desires position with good opportunity for advancement.

2 Mechanical engineer, manager, having disposed of interest in large foundry and machine shop, desires to represent some good lines of machinery; could engage in designing or selling engines and mining machinery in any locality, New York preferred.

3 Mechanical engineer, with long experience, desires position as chief engineer, superintendent, or designer. Would be willing to invest some capital in established business.

4 First class designer, steam hydraulic and general machinery, is open for an engagement. Can take charge of and systematize drawing office. A–1 references.

5 Mechanical engineer, experienced in foundry, paper mill, crushing plants, stamp mills and cyanide plants. Responsible charge of drafting room.

6 Junior member, technical graduate, five years experience in designing, selling, inspection, erection, and general office work of a technical nature, desires position as assistant engineer, sales engineer, or office man.

7 Superintendent of construction, desires permanent position with concern doing their own construction work, to take entire charge of same, and by systematic methods, reduce expenses and keep accurate record of costs. Wide experience in building construction of every description.

8 Technical graduate, 28 years old desires permanent position in the vicinity of New York City. Four years experience in drafting and general engineering.

9 Experienced draftsman M. E. Lehigh, 1896; and designer; estimator and engineer of such departments in manufacture of turbines, pumps and high head wheels. Charge of correspondence; good general experience.

10 Graduate, London Polytechnic; five years shop, four years drafting room. Would like, for experience, position in marine lines as assistant engineer.

11 Manager, superintendent, or assistant; graduate Worcester Polytechnic; 18 years experience, design and manufacture of light and medium interchangeable machinery; plant construction and maintenance.

12 Member; 16 years experience in electric railway and lighting, as electrical engineer, superintendent and general manager.

13 Position desired with engineering company in design and building of Portland cement mills, or cement manufacturing company, wanted for experience rather than salary.

14 Electric railway and power station work; served as assistant to mechanical engineer in similar lines.

15 Member desires change of position along line of general superintendent or works manager. Familiar with handling large propositions.

16 Member, Cornell E.E. and M.M.E. One year assistant engineer light plant, ice factory and water works; five years assistant professor of mechanical engineering; one year wood-preserving; two years railroad signaling; and eighteen months steam turbine, power station, ice and cold storage plant design and construction.

17 Machine designer on special machinery and general factory equipment, power transmission and experimental work.

18 Successful manager or superintendent, age 32, American, married, salary $2500–3000. Foundry or machine shops; plant equipment. Excellent organizer and disciplinarian; competent in manufacturing, sales, buying, secretary; applied technical training supplemented with broad experience in industrial engineering; A–1 executive, strong personality.

19 Industrial plant construction, superintendence or teaching. Experience in design of power house work.

20 Turbine expert; fifteen years experience in land and marine turbine work. Traveled extensively for special study in this line.

21 Mechanical and electrical engineer, Cornell graduate, five years experience in the design and construction of electrical hoisting machinery; three years in charge of a steam and electric power plant; five years on general mechanical engineering work, including building and power plant design, construction and the purchasing of material.

22 Architect and engineer, graduate Columbia University, open for engagement January first; experienced in the design and construction of power houses, water-works, railroad, mill and other classes of buildings; four years with Westinghouse, Church, Kerr and Co., New York City.

23 Cornell M. E., two years on the design and installation of power plants and heating systems.

24 Competent engineer desires charge of repairs and maintenance of plant equipment, including buildings, power plant and design of special machinery.

25 Young architect desires position as superintendent of construction or in office of engineering firm or railroad company. Has had four years experience designing and detailing; also four years experience on power-house work and reinforced concrete, with large engineering firm.

26 Junior, graduate of Massachusetts Institute of Technology, aged 34, two years experience in steel works, seven years as chief engineer of large works in Pennsylvania; experienced in design, shop work and construction.

27 Member with splendid record in engineering and sales departments of large engine works, desires position along similar lines.

CAR LIGHTING

By R. M. DIXON, NEW YORK
Member of the Society

It has been a recognized necessity from the beginning of railroad operation, because exclusiveness became impossible through the common carrying feature of the service, that the interiors of railroad cars should be lighted at night. The managers of railroads have not been content to supply a meagre illumination, but most cars are well lighted and in many instances they are elaborately illuminated.

2 The first railroad coach, drawn by a horse, on the road between Darlington and Stockton, was lighted by a penny candle and the driver is characterized by Samuel Smiles, in his "Lives of George and Robert Stephenson," as "the inventor of carriage lighting on the rail," the passengers being indulged with light in darkness.

3 Candles were first used for car lighting, but it is probable that since the time of their general use no uniform system of lighting can, or will, become exclusively used; there will always be some railroad service in which advanced and modern methods of lighting may be used, and other branches of railroad service where older methods will be retained.

4 It has, however, been proved that it is not necessary to employ generally a system of lighting which renders cars independent of supply plants, and further that if a car carries four or five nights' requirements, it is sufficient. Thus, the Pintsch compressed gas system has been found to meet the requirements of the railroads of the world to an extent covering probably 80 per cent of the passenger cars in service, notwithstanding the fact that the Pintsch system is absolutely dependent for its light upon stationary supply plants.

To be presented at the regular Monthly Meeting, Tuesday evening, January 14, 1907, of The American Society of Mechanical Engineers.

The professional papers contained in Proceedings are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present. They are issued to the members in confidence, and with the understanding that they are not to be published, even in abstract, until after they have been presented at a meeting. All papers are subject to revision.

"The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions." C 55.

5 Electric light is popular, due to the impression that it is peculiarly safe; that it is more brilliant and modern than any other method of lighting and that it does not heat the car and vitiate the atmosphere. These claims are not applicable to electric light only. Oil gas lighting, with proper appliances, is equally safe, and both gas and gasolene vapor systems excel electricity in brilliancy. Almost all of the oil and gas lamps are so arranged as to discharge their products of combustion outside of the cars and thus assist in the ventilation to a degree far over-balancing the heat developed, which need not exceed that of two pounds of coal per hour.

6 The continued use of candles for car lighting is prohibitive, because the best light possible is insufficient and because of the large expense involved.

7 Oil lamps are, and probably will be, continued in use on a considerable percentage of passenger cars in America, but the illumination is inadequate, and after a few hours use they show a radiation of but about 50 per cent of the original amount of light without any decrease in the oil consumption. Moreover, the smell of the oil, the smoked chimneys, expensive repairs and high cost of maintenance, to which must be added the settlements of claims to wearing apparel and belongings of the passengers as well as the cost of carpets, etc., ruined by the dripping of oil, makes the use of oil lamps undesirable where other and more modern methods of lighting can be used.

8 The Pintsch oil gas system is the most extensively used system of car lighting, and notwithstanding the number of cars now lighted by other methods, it is an unquestionable fact that more cars are lighted with the Pintsch system of lighting than with any other light at any time. The gas is produced by the fractional distillation of petroleum oil and the apparatus is especially arranged to produce gas which will lose a minimum amount of its illuminating value in the compression to which it is afterwards subjected, namely, about 200 pounds per square inch. It is stored at the plants under this pressure in vessels which are connected by pipe lines to the railroad yards to which it is charged by equalization from 150 to 180 pounds into the tanks suspended from the floor framing of the cars.

9 At the present time there are seventy of these plants established; their distributing systems being connected with about 350 railroad terminals, thus enabling managements of railroads to apply gas lighting to cars without expense for gas supply plants.

10 In some of the Pintsch plants local gas companies have interests with the Pintsch company and the plants are operated jointly. There are some cases where the Pintsch Company has as partners

the railroad companies, while in other locations the Pintsch Company owns and operates the plants itself.

11 The gas furnished is measured by the increased pressure in atmospheres times the volume of the tanks on cars in cubic feet, the railroad company paying for the net amount of gas supplied to the tanks. Car tanks are of welded steel, 21 inches in diameter and either 8 feet 6 inches or 9 feet 6 inches long, the shorter holder contains 19 cubic feet per atmosphere and the longer one 21.18 cubic feet per atmosphere. In many instances more than one tank is applied to a car. The normal charging pressure is 10 atmospheres. There is a

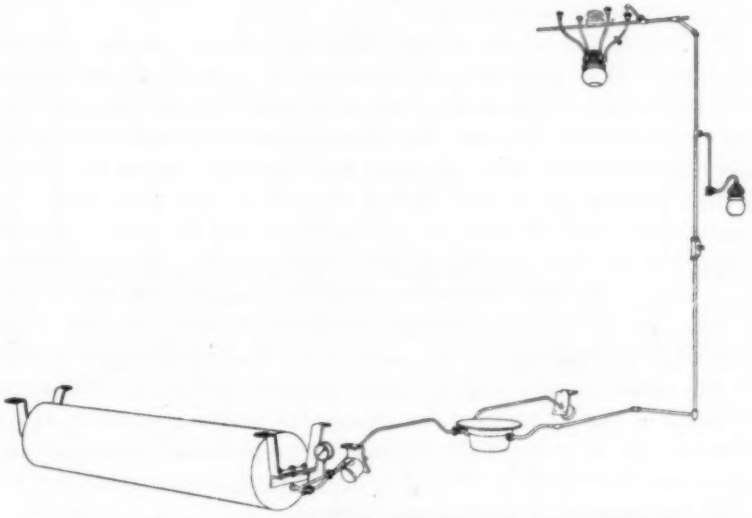

FIG. 1 DIAGRAM OF PINTSCH GAS EQUIPMENT USING MANTLE LAMPS

filling valve on each side of the car for convenience in filling, and a gage located near the tank underneath the car indicating the initial and final pressures. See Fig. 1. The high pressure piping system consists of a $\frac{1}{4}$ inch extra heavy wrought iron pipe extending across the floor of the car to the filling valves with a branch to each tank and a short branch to the reducing valve or pressure regulator, located underneath the car near the tank. From the pressure regulation a $\frac{1}{2}$ inch standard wrought iron pipe conveys the gas underneath the floor of some convenient point and then to the roof where a distributing pipe extends on the outside with branches to each lamp.

12 Until recently the gas has been burned in standard four flame lamps of various designs finished to harmonize with the interior con-

struction and ornamentation of the cars. The aggregate consumption of the four flame lamp is about three cubic feet an hour and the illumination about thirty-three candles light. About three years ago, by the development of an inverted mantle which is sufficiently substantial for railway service, it became possible to get 90 candles light from the same consumption of gas, that is, three cubic feet per hour. This required the use of a cluster of four mantles but still more recently a mantle has been developed which, with a consumption of two and one eighth cubic foot per hour, gives from 95 to 100 candles light, or per cubic feet of gas nearly fifty candles. At the standard selling price of the gas the cost of operation of these lamps is but one and one sixteenth cents an hour.

13 Mantle lamps are giving great satisfaction to the railroad managers. More than three thousand cars in America are now equipped with them and they are securing quite a general adoption in Europe. The Prussian State Railway Administration has contracted for about thirty-eight hundred new cars fitted with mantles, and for the change of their present equipment before the end of the year 1909. In France more than 10 000 cars are equipped and on order. Pintsch equipment has been applied to more than 160 000 cars, aggregating more than 1 000 000 center lamps and more than 400 000 tanks: 33 000 cars have been equipped in North America and the entire equipment is available for use with an expense of but $100 or $125 per car, thereby increasing the light three fold and reducing the consumption of gas 30 per cent, increasing the carrying capacity of the tanks and the capacity of the established gas plants about 40 per cent, thus more than trebling the value of the equipments owned by the railroad companies as light giving factors.

14 The behavior of Pintsch gas in wrecks has been commendable. The gas itself requires a high temperature for ignition, and the flame temperature is comparatively low. Moreover, it is extremely difficult to light the gas when escaping under pressure, the tendency being to extinguish a torch or light brought near it. Further, the quantity of Pintsch gas carried on a car is so limited and the gas is so free from vapor and its diffusion so rapid, that in the case of the rupture of a tank or the pipe connections, it is so quickly dissipated that an explosive mixture or a combustible condition is not readily obtainable.

15 For those cars which are in service and which do not reach Pintsch supply plants, a system has been developed for lighting by the use of carbureted air in connection with the incandescent mantle lamps. This system has been made possible by the mantle lamp

development for railroad service. One disadvantage of the earlier systems was the low luminosity of air gas in cold weather. With incandescent mantles it is possible to obtain good results with gas that is non-luminous. Another disadvantage of the old systems came from the fact that a carburetor had to be placed directly over each lamp as it was impossible to have one large carburetor supply all of the lamps, owing to the collection of condensation in the pipes from a fall in temperature.

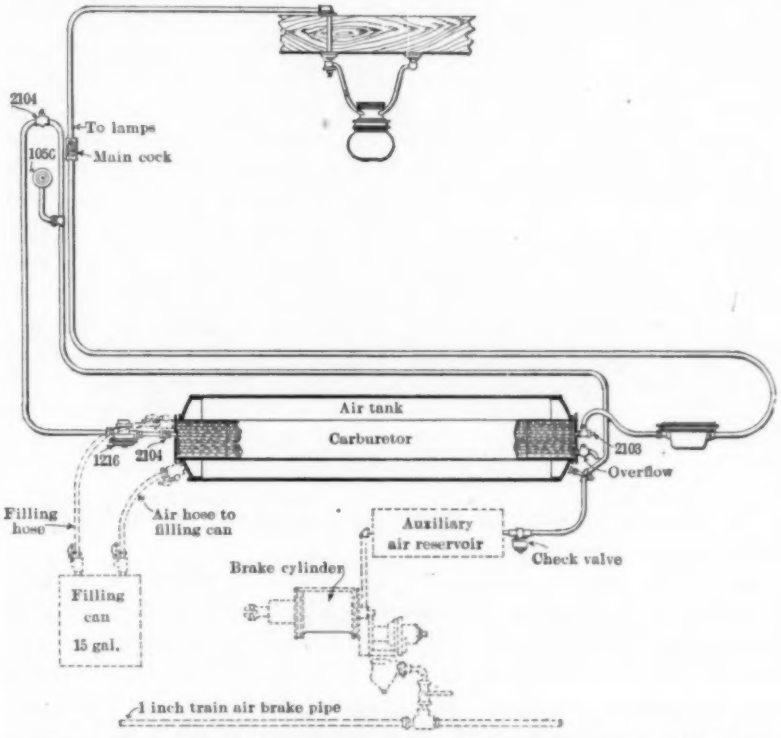

FIG. 2 DIAGRAM OF INCANDESCENT VAPOR SYSTEM OF CAR LIGHTING

16 If the gas be non-luminous in quality, no condensation in the piping can take place at ordinarily low temperatures. In this new system the gas is always of this quality. This uniformity of quality is accomplished by varying the pressure under which the gas is generated in the carburetor, in accordance with the temperature, making it possible to use a carburetor of substantial construction under the car, and distributing the gas to the lamps by a piping system similar to that for cars lighted by Pintsch gas.

17 The operation of the system is as follows: air is taken from the auxiliary air brake reservoir, see Fig. 2, through a check valve to the air storage tank, and from this tank up to the saloon of the car where a pressure gage and shut off axle are placed. This gage shows the pressure of air in the air storage tank. From the saloon the air passes to the high pressure regulator which delivers a pressure on the carburetor in accordance with the temperature. In passing through the carburetor the air takes up sufficient gasolene vapor to make the proper gas. From the carburetor the gas passes through a low pressure regulator which reduces the pressure to that suitable for burning in the lamps. The lamps are similar in design to those used for Pintsch gas, and use the same mantle. The carburetor is contained within the air storage tank and is formed by a 12 inch pipe through the center of a steel holder 21 inches in diameter. The ends of the pipe are brazed to the heads of the holder and closed by iron plates securely bolted on. The pipe is packed full of absorbent wicking to hold the gasolene. The air passing through this wicking takes up the proper amount of vapor to form the gas. By this construction the carburetor is well protected by the walls of the air tank.

18 A combined air tank and carburetor, 21 inches in diameter by 8 feet 6 inches long, has when charged, 20 gallons of gasolene and will supply five 100 candle power lamps for at least 200 hours.

ELECTRIC LIGHTING

19 Electric lighting for steam railroad cars is accomplished by either one of three methods:

20 *a* The system of electric train lighting in which the dynamo is carried in the baggage car, and driven by an engine supplied with steam from the locomotive. By this method it is necessary to have storage batteries carried on each car or in the forward car, to maintain the lights in case of the detachment of the locomotive and consequent lack of steam supply. It is customary to use a 25 kilowatt machine and expert attendance is a practical necessity. All cars are dependent for electric light upon the car which has the dynamo and require some other means of lighting when detached from the electrical supply.

21 *b* Another method of lighting cars by electricity is by means of the storage batteries; these being charged at terminal plants. When greater improvements are made in storage batteries, this will be found to be the ideal system, as no special light producing mechanism is required on the cars, but with the present commercial bat-

teries which require from six to eight hours for charging for eight or ten hours light, the expense, weight and depreciation of the batteries all make the system costly, and as a lighting means, comparatively feeble.

22 *c* The axle driven dynamo system, which provides a dynamo mounted upon a car truck and driven by the axle. A set of storage batteries which are charged by the dynamo and maintain the lights when the latter is still or revolving at a speed below that at which it will generate current of sufficient voltage; a regulator to maintain the proper charging current for the batteries regardless of the increase or decreased speed of the dynamo; a switch to prevent the discharge of the batteries through the dynamo when the latter is not generating and a lamp regulator to compensate for the voltage difference of the charging current and discharge current from the batteries to the lamps. Consideration has also to be given to maintain the proper polarity of the charging current to the battery, regardless of the direction of revolution of the dynamo.

23 The earliest use of this system in America, the idea of which is to make each car independent of a stationary plant or train for lighting, was made on the Central Railroad of New Jersey in the year of 1890, and notwithstanding the comparatively large amount of mechanism involved in the axle driven electric lighting systems, some satisfaction has been obtained.

24 The distribution of light is a subject sometimes ignored. The source of light, if intense, should not radiate directly into the faces of people, for the result is a contraction of the pupils of the eyes and a decreased general illumination effect. The desirable effect is, of course, an approach to indirect daylight and a source of light should, therefore, not be less in intensity and should not greatly exceed four or five candles per square inch. Increased illumination should be obtained by increasing the area but not the intensity of the source of light.

25 For the general illumination of passenger cars the most satisfactory results are obtained by suspending lamps from the ceiling with the light centers as high as possible and avoid considerable deep shadows on the lower deck. Lights so placed are high enough to be somewhat out of the direct range of vision. Center lamps of considerable power are more satisfactory than a great number of small lights for the many shadows caused by the latter are annoying. Lights placed on the sides of cars such as reading lights, berth lights, etc., should always be shaded, or they detract from the general illumination.

26 Pintsch gas, used in regenerative four-flame lamps, has an intensity of candles per square inch not much in excess of average diffused sunlight. When Pintsch gas is used in mantles, the intensity of the incandescent is about fifty candles per square inch and the best effects are produced by using shades of opal glass, thus the thirty candle power light radiated from a spherical mantle about $\frac{7}{8}$ inch diameter is dispersed by an opal sphere about 4 inches diameter and becomes with an allowance for loss, a light source of approximately two and a half candles per square inch and the light of the 100 candles from a spherical mantle $1\frac{1}{8}$ inch in diameter is dispersed by an oblate spheroid shade over an area of about fifty square inches, with a resultant radiation of about two candles per square inch. With either of these arrangements a most satisfactory effect is produced, and their use has met general approbation.

27 The use of reflectors for interior illumination requires much care. The light must not be projected so as to brightly light some parts at great expense to other parts. Cars especially must not be lighted for reading only, but require a general illumination. The interiors are handsomely finished and should not be left dark, and cheerfulness demands brightness overhead.

A JOURNAL FRICTION MEASURING MACHINE

By HENRY HESS, PHILADELPHIA, PA.
Member of the Society

THE PURPOSE OF THE MACHINE

This machine was devised primarily to try out ball bearings by running them under various loads and speeds; the loads being applied either radially (normal to the shaft axis), axially (parallel to the shaft axis-thrust), or both simultaneously.

2 As it was desirable to note the behavior of the bearing throughout a test, some measure of its quality was necessary. A ball bearing or, for that matter, any bearing, must be capable of carrying its load without failure, and incidentally should waste the smallest possible energy in friction.

3 The measures of bearing quality would therefore be *a* carrying capacity and *b* frictional resistance.

4 This machine is capable of applying radial loads up to a maximum of 15 000 pounds, and thrust loads up to a maximum of 10 500 pounds under rotative speeds ranging from 150 to 2500 revolutions per minute. It is capable of measuring the coefficient of friction when radial load only is applied, when thrust load only is applied, and when both radial and thrust load in any relative amount are applied.

5 The scheme of the machine is very simple as is apparent from the skeleton diagram Fig. 1.

6 The bearing A to be tested is mounted at the forward end of a shaft that is rotated by a reversible motor. The bearing box is held in an embracing strap AB which is hinged to the rod BC. The upper end of rod BC is connected to a system of weighing levers typified in the diagram by a single beam CE with its weight Q.

To be presented at the Detroit Meeting (May 1908) of The American Society of Mechanical Engineers, and to form part of Volume 30 of the Transactions.

The professional papers contained in Proceedings are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present. They are issued to the members in confidence, and with the understanding that they are not to be published, even in abstract, until after they have been presented at a meeting. All papers are subject to revision.

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7 So long as the bearing is at rest, the line from the center of the bearing A to the hinge of the strap, and from this hinge to the weighing beam attachment C will form a continuous straight line AC. Rotating the bearing in the direction of the arrow will deflect the strap AB and rod BC as shown; the journal friction is the deflecting force and is balanced by the weight Q acting through the weighing beam. The deflection of AB and BC from the straight line is a measure of the deflecting force; that is, of the journal friction.

8 The arrangement for applying thrust load is shown in skeleton diagram in Fig. 2. The bearing A is carried as before at the end of a shaft, through whose bore a wire G is passed; the forward end of this wire carries a yoke F that rests against the outer race of the bearing so that the load pulling on the wire through a system of weighing levers puts a thrust load on the bearing. A delicate balance with

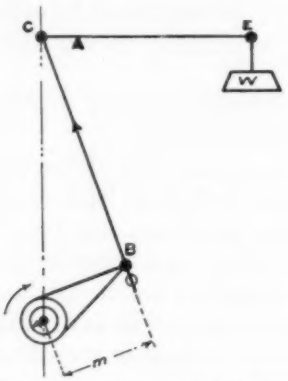

FIG. 1 SKELETON OF RADIAL FRICTION MEASURING ARRANGEMENT

pointer and weight pans is attached to the yoke. The journal friction tends to rotate the yoke and twist the wire until the latter's torsional resistance balances the friction. Restoring the balance by weights in the high pan measures the friction directly.

9 When the journal is submitted to combined radial and thrust load, the deflection of the strap AB and rod BC of Fig. 1 will measure the total friction.

PRECAUTIONS OF DESIGN

10 Since the coefficient of friction of a good ball bearing is as low as 0.0015 referred to the shaft diameter, it follows that errors of the machine may be but small. The application of loads up to 15 000 pounds demands a decidedly robust construction. The general scheme of the radial load friction apparatus of Fig. 1 is in principle

modeled on a design of Professor Stribeck's, but differs from his in the use of rod *BC* as a tension member instead of a compression strut as he had it. Obviously, a strut of any length (36 inches in this machine) to transmit 15 000 pounds would have to be very heavy and cumbersome.

11 In Stribeck's machine the deflection for *AB* and *BC* from the straight line is measured by a system of multiplying levers; these necessarily involve frictional resistances, which, though slight in themselves, are nevertheless undesirable as compared with the friction of the bearing under test. A direct reading of the deflection itself by means of a microscope reading to one ten thousandth of an inch is substituted.

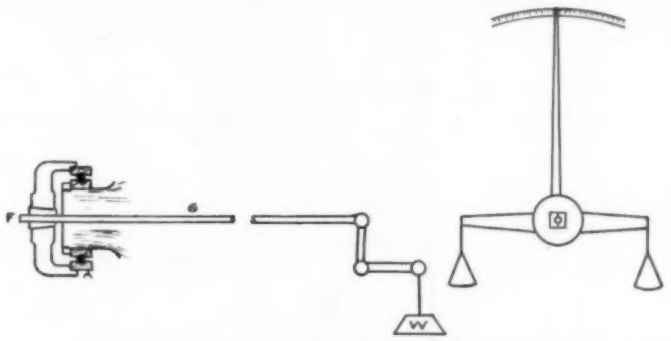

FIG. 2 SKELETON OF THRUST FRICTION MEASURING ARRANGEMENT

12 The various pivots are all knife edges. The beams and rods themselves were carefully calculated to balance and then corrected in the actual building. This assured the essential high degree of sensitiveness.

13 Attention may here be drawn to the fact that the frictional resistance of the shaft carrying the bearing to be tested does not affect the result in any way. It would otherwise be obviously impossible to measure the friction of a bearing taking on only a few hundred pounds load, and in the same machine, another taking fifteen thousand pounds. As the shaft supporting bearings must be capable of safely carrying this high load, their frictional resistance would otherwise totally overlay and obscure the resistance of the smaller bearings under test.

14 The point *C*, Fig. 1, should be vertically over *A* since the deflection of *AB* and *CB* is measured horizontally. As there is a possibility that *C* may not occupy this absolutely correct position and

as an error to one side or other would increase or decrease the apparent deflection reading, the bearing is run in both directions for each test; the arithmetical mean of the two readings gives the correct reading.

MAIN PROPORTIONS

15 By consultation with Riehle Brothers Testing Machine Company, the firm which built the machine to the author's design and specifications, a total lever ratio of 1 : 50 was fixed for both the radial and thrust load applying systems.

16 In Fig. 1 let m be the distance from A to BC-- normally to BC, r the radius of the bearing at the bore or shaft surface and μ the coefficient of friction referred to radius r. Let P equal the load acting along BC.

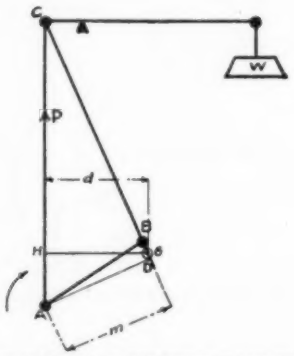

FIG. 3 SKELETON OF RADIAL FRICTION MEASURING ARRANGEMENT

There will be equilibrium when

$$P_m = P\mu r$$
$$m = \mu r. \qquad [1]$$

m is therefore directly proportional to the frictional resistance of the bearing under test. The shaft radius is chosen as the lever arm to which the friction is referred, as the friction acts at that lever arm in a plain journal. In a ball bearing or roller bearing the friction really acts at the tracks on which the balls roll, but for purposes of comparison with plain bearings it is referred to the bearing bore, which is identical with the shaft diameter.

17 The determination of the friction by direct reading of the deflection m was not quite convenient from the mechanical arrangement of the parts. A line was therefore scratched at a point lower

down on the rod BC at G (see Fig. 3). The various dimensions chosen were

$$AC = 45 \text{ inches}$$
$$BC = 36 \text{ inches}$$
$$AB = 9 \text{ inches}$$
$$CG = 37.5 \text{ inches.}$$

This gives

$$AC : CG = 6 : 5$$

so that

$$\frac{AC}{CG} = \frac{6}{5}$$

18 It is clear from Fig. 3 that

$$\frac{AD}{AC} = \frac{HG}{CG}$$

and substituting m for AD, d for HG, $\frac{6}{5}$ for $\frac{AC}{CG}$ gives

$$m = \frac{6}{5} d$$

As it was found that $\mu = \frac{m}{r}$

$$\mu = \frac{6}{5} \frac{d}{r} \qquad [2]$$

This equa. 2 is used for determining the coefficient of friction μ from the reading of the observed linear deflection of point G. As thrust loads are applied up to a maximum of 10 500 pounds and the friction is determined by weighing the deflecting force, it follows that a wire heavy enough to apply the maximum load would be deflected so little under the lighter loads as to demand extremely sensitive weighing apparatus. Several wires of different diameters are therefore used to cover the range.

19 When determining the friction due to simultaneous radial and thrust loading the microscope reading method, as used for the radial loading alone, is employed. But the torsional resistance of the thrust applying wire opposes the bearing friction as a deflecting force and so injects an error into the observation. This error is to be kept down to an amount which is negligible, say 0.5 per cent, by the suitable relative proportioning of radial load, thrust load and torsion wire; these are determined as follows:

20 The "*Taschenbuch des Verein's Hütte*" gives for straight torsional springs:

$$M_t = \frac{d\ \pi\ w^4\ G}{32\ t}$$

M = torsion moment
w = wire diameter
G = modulus of shear = 11 000 000 pounds per square inch
t = length of wire = 40 inches
d = arc through which wire is twisted

As the angular deflection of the wire is very small the arc may be considered a straight line without introducing a material error.

Inserting values gives

$$M_t = \frac{d\ \pi\ w^4\ 11\ 000\ 000}{32\qquad 40} = 27\ 000\ d\ \ w^4$$

In the apparatus, Fig. 3, the frictional moment

$$M_f = P\ m = \frac{P\ 6\ d}{5}$$

21 The percentile relationship of the torsion and friction moments is defined by

$$E = \frac{M_t}{M_f}\ 100, \text{ and by substitution}$$

$$E = \frac{27\ 000\ d\ \ w^4}{P\ \frac{6}{5}\ d}\ 100 = 2\ 250\ 000\ \frac{w^4}{P}$$

22 For a desired error of 0.5 per cent we have

$$0.5 = 2\ 250\ 000\ \frac{w^4}{P} \text{ and}$$

$$P\ = 4\ 500\ 000\ w^4$$

23 A series of wires for applying thrust loads were specially drawn of high grade stock and the following table worked up for them.

TABLE I

Wire gage	Wire diam. in.	Max. thrust load lbs.	Min. radial load P for max. error of 0.5 per cent lbs.	Tensile stress in wire due to max. load lbs. per sq. in.
32 Music	0.086	1000	245	172 000
8 B & S	0.128	2000	1200	155 000
6 B & S	0.162	3000	3000	145 000
4 B & S	0.204	5000	7500	155 000
3 B & S ...	0.258	7500	12380	181 000

24 Smaller radial loads than these given in the table can be used, but in that case the error becomes larger, so that readings must be taken by both the microscope and the torsion weighing scale; it was not thought worth while to incur this complication.

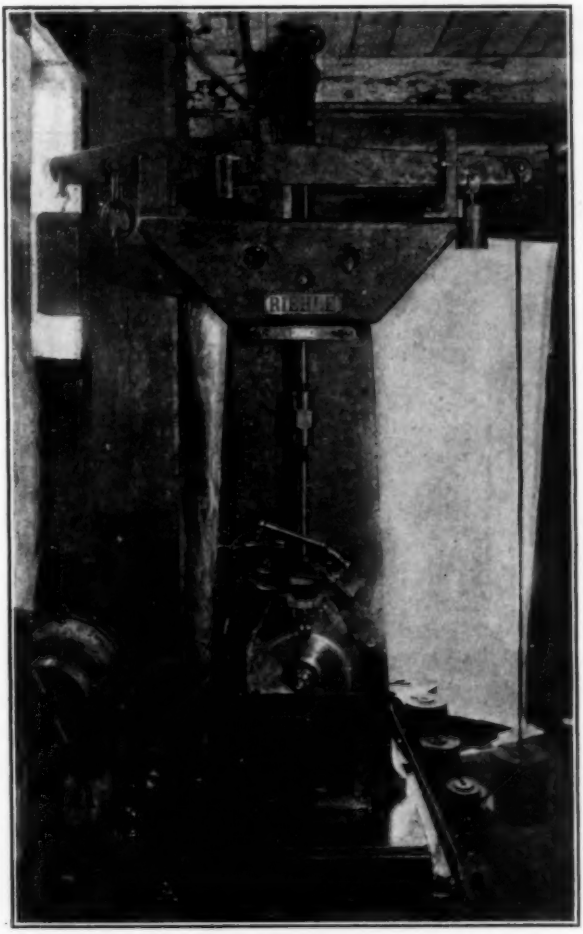

FIG. 4 MACHINE ARRANGED TO MEASURE THE FRICTION OF A RADIALLY LOADED BEARING

THE ACTUAL MACHINE

25 Fig. 4 is a photographic view showing the machine arranged for testing a bearing under radial load only. Fig. 5 shows it for thrust load only.

26 The spindle is mounted on two ball bearings in the base of the main frame. As this spindle has to carry loads at its outer end up to 15 000 pounds, a large ball bearing is called for; as thrust loads up to 10 500 pounds must be taken care of, a collar thrust bearing is included in the spindle mounting.

27 The regular working of the machine entails a most severe trying out of these spindle bearings; the combination of 15 000 pounds load and the high speeds employed is particularly trying.

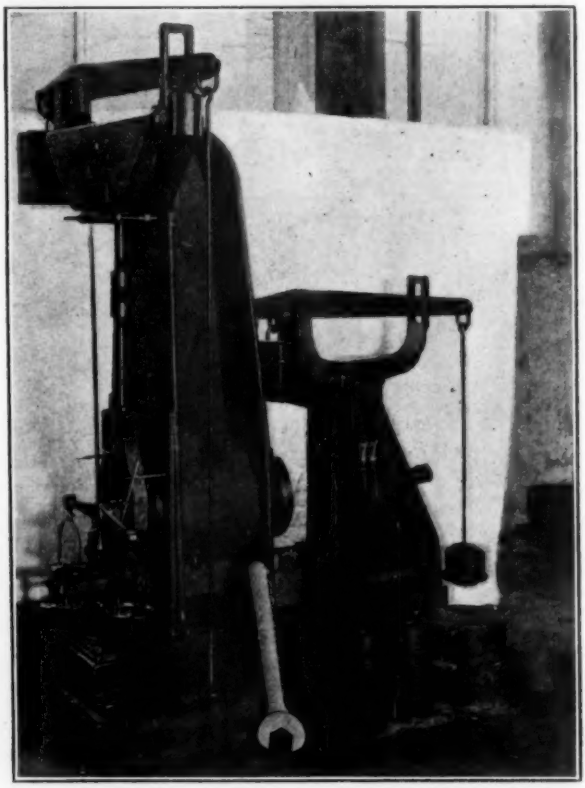

FIG. 5 MACHINE ARRANGED TO MEASURE THE FRICTION OF A THRUST LOADED BEARING

28 The tight and loose pulleys at the spindle end are belted to an interpolar variable speed motor whose range is increased by an exchange of pulleys.

29 An arbor, inserted into the front end of the spindle, takes the bearing under test on its nose. Bearings of larger bore are bushed

down to suit the arbor nose. Arbors of successively larger noses are provided to make sure there is no undue deflection of the nose.

30 The outer race of a ball bearing, or the box of a plain bearing, is carried in the yoke which is connected to the load applying rod by knife edge pivots. The rod itself is made of two pieces connected by a differentially threaded turnbuckle. The upper end of the rod is connected to the weighing beam system mounted on the top of the machine. With the bearing in place and the proper weights hung, the turnbuckle is adjusted until the index near the right hand end of the long top beam lines up with the mark showing that all is in proper balance.

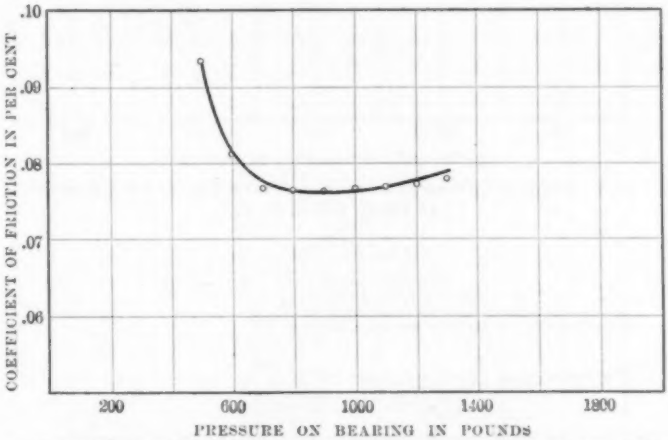

FIG. 6 FRICTION CHARACTERISTIC OF A COLLAR THRUST BALL BEARING AT 495 R. P. M.

31 A microscope with focal and transverse adjustments is horizontally mounted to observe the deflection of the bearing yoke and load rod. It will read ten thousandths of an inch on a fairly open scale ($\frac{1}{32}$ inch divisions), so that interpolations are quite possible. The crosshairs in the eyepiece are brought over the line on the rod end with the bearing at rest; slight vibration by hand ensures the correct alignment of the bearing center, yoke pivot and upper rod pivot. While running, the microscope is traversed horizontally until crosshairs and reading line again coincide. In practice it is found that at certain speeds the vibrations of the framing and of the loading system coincide in phase occasionally so that the reading line swings rather far to either side; these oscillations die down as the phases fall out of step so that sufficiently definite readings are secured. The reading line is a very fine scratch on a highly polished steel plate.

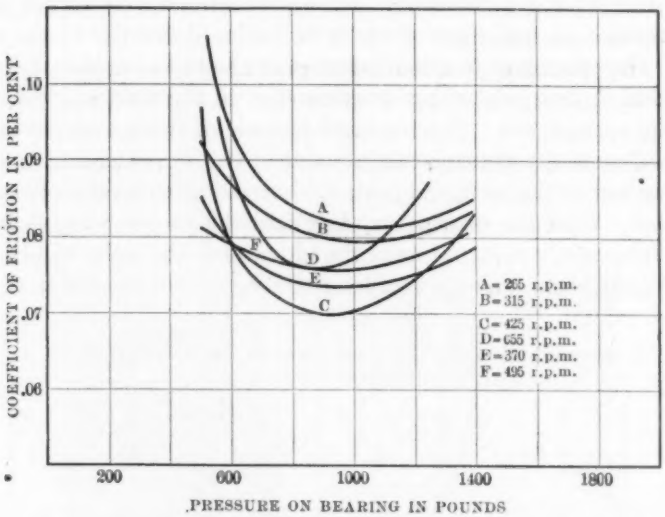

FIG. 7 FRICTION CHARACTERISTICS OF A COLLAR THRUST BALL BEARING AT 265 TO 655 R. P. M.

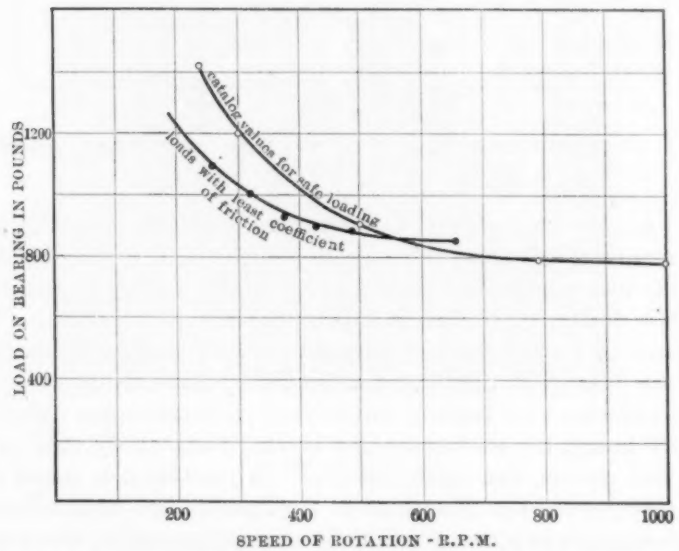

FIG. 8 LOAD AND SPEED CHARACTERISTIC OF A COLLAR THRUST BALL BEARING

Direct illumination from an incandescent lamp has given the best results—better than light reflected through the objective by a prism in the microscope barrel.

32 The thrust load is applied to the bearing under test by a yoke that rests against the outer race or box. This yoke takes a wire rod by taper clamps. The wire passes through the hollow spindle to the upper arm of a bell crank weighing lever, being clamped to that by similar taper jaws. A tension applying screw is carried by this lever. The entire thrust load applying scale is, with the exception of the first bell crank beam, of standard construction and conveniently arranged on the back of the base.

33 The photographic view Fig. 5 shows quite clearly the arrangement of the weighing beam that is attached to the loading yoke, together with its weight pans and long indicating needle. The scale responds sensibly to weights of 0.0005 pound placed in the pans.

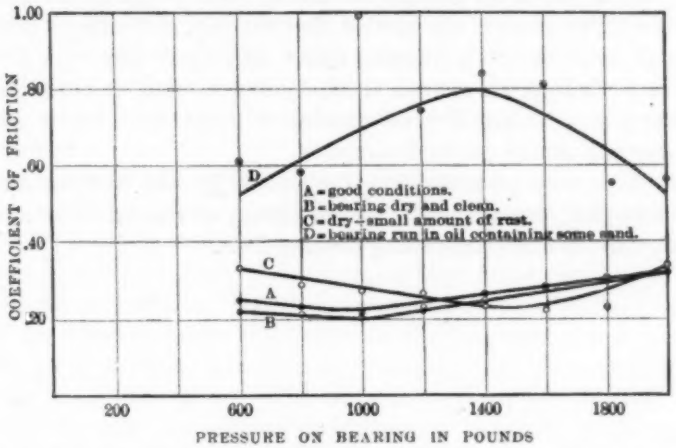

FIG. 9 FRICTION CHARACTERISTICS OF A RADIAL LOAD BALL BEARING UNDER NORMAL CONDITIONS AND UNDER ABUSE

TYPICAL BEARING TESTS

34 As this is primarily a description of the friction testing machine and not of friction tests, conclusion will be made with a few typical tests that illustrate the range and accuracy of the machine.

35 Fig. 6 gives the results of a test of thrust bearing 9 *r* at 495 revolutions per minute under loads ranging from 500 to 1300 pounds. One point only, at 1000 pounds falls outside of the range of a fairly smooth average curve, with the friction coefficient ranging from 0.075 to 0.080 of one per cent.

36 Fig. 7 gives similar curves for various speeds ranging from 265 to 655 revolutions per minute, while Fig. 8 gives a curve deduced

from the observations and shows graphically the relationship between load capacity and speed, that load being considered the correct one for a certain speed at which the coefficient of friction is least.

37 The behavior of radial bearing No. 308 under radial loads only, as measured by the coefficient of friction is plotted in Fig. 9. This was tested, first immersed in oil, then thoroughly washed clear of oil in gasolene and dried, then slightly rusted.

38 The rated load for steady load and uniform speed is 1400 pounds. The perfection of finish of the races and balls and truth of the parts is shown by the very small difference between the oiled and dry bearing. At about 25 per cent overload the influence of deformations in their effect on the true rolling became manifest in a crossing of the oil and dry curves with the latter becoming higher. As was to be expected, the slightly rusted bearing showed the higher friction; but the unexpected result is shown of this friction becoming less than that of the unrusted bearing at about 1400 pounds; but between 1800 and 2000 pounds the friction rises sharply, indicating a probable early destruction of the bearing under prolonged running. Because dry and oiled curves show a similarly low friction, it is not safe to deduce the permissibility of running without oil. Prolonged dry running will surely prove destructive.

39 It is with pleasure that I acknowledge the efficient aid rendered by Mr. Messner in the detail design of the machine and Mr. Batt's careful and painstaking observations.

DISCUSSION

INDUSTRIAL EDUCATION

By W. B. Russell, Published in October Proceedings

Mr. C. W. Cross The system of apprenticeship described by Mr. Russell is the result of years of experience and experiment by Mr. Deems before he established the plan in March 1906.

2 The foundation principles of the plan have stood the test of time and the only changes found necessary have been in the way of additions to the course. There is more enthusiasm now than there was a year and a half ago. It means that in future the shops will be supplied with workmen who have been trained in the theory and practice of the business, and the efficiency will be correspondingly increased.

3 The need of a better system of training mechanics for the railroad service is imperative, and I think need not be argued with any one in touch with the situation. The railroad company receives direct benefits by having the men quickly made familiar with the standards of practice. They are brought into close contact with the drafting room and also into intimate relations with the shop draftsmen. The mutual understanding between the company and the men is greatly improved. The ambition of the men is aroused.

4 The recent awakening of interest in industrial education and the inquiries and observations from all directions indicate that other railroads and manufacturing concerns are now giving this subject the consideration it deserves and that the day is not far distant when each company will have a fully equipped apprentice system as an integral part of its organization.

Mr. Geo. W. Rink In establishments where it is necessary for mechanics to work with drawings, in order to insure interchangeable parts of machinery and also the production of new work accurately, as laid out by the draftsman, it is absolutely necessary that the young men who are growing into manhood and learning the various trades be given the necessary instruction in drawing which will permit them to produce the work accurately and speedily, and, at the same time,

reduce the responsibility of the foreman so far as explaining the drawings is concerned; thus giving him more time to consider other matters which may be more urgent or important.

2 Since the establishment of correspondence schools and free evening schools in our larger cities it has become possible for mechanics who are anxious to advance themselves in their chosen field, to obtain a comprehensive knowledege of mechanical drawing and elementary mechanics. While there are a few who have taken advantage of this course, there are still a very large number who could not avail themselves of these opportunities. The result is that a very large majority of mechanics today do not understand drawing and never will understand the subject until they have been compelled, while serving their apprenticeship, to study. This deficiency is quite apparent in almost any railroad repair shop of the country. The author, who has served his apprenticeship in such a shop, recalls the fact that most drawings of locomotives and their details, at that time, were kept in the superintendent's office, and occasionally a print for the mechanic to work from would find its way into the shop. Repairs were made in a haphazard sort of way. If a certain part of an engine was giving trouble, it was repaired in one way on one division and other methods would probably be tried out on the other divisions. The result was that eventually no two engines of the same class would be alike, due to difference in ideas of different master mechanics.

3 Where in years past an occasional drawing would be seen in a railroad shop, in passing through a modern shop, you will see drawings on almost every machine and work bench. The majority of young men seeking positions in railroad shops have had little or no training in drawing or the principles of mechanics; and, in order that these young men may become productive and efficient mechanics, it is the duty of officials to see that schools are established and proper instruction given, so that the future mechanics may be efficient.

4 With this object in view, the Central Railroad of New Jersey established in October 1905, at its principal shops at Elizabethport, N. J., a school for blacksmith, carpenter, machinist, pattern-maker and boiler-maker apprentices, which has proved of great benefit to the company. The school has been evolved by Mr. B. P. Flory, mechanical engineer, member of the Society, acting under the direction of Mr. Wm. McIntosh, superintendent of motive power.

5 The organization of this school was accompanied by a ruling that all boys applying for positions as apprentices must pass an examination in reading, writing and arithmetic, and present three

letters of introduction from business men in the community in which they reside, testifying to their moral character. The minimum age limit was established at 17 years. All of the apprentices are required to attend school throughout their four years of apprenticeship. The school is divided into three classes, meeting, during working hours, from 12:45 to 2:45 p.m., on Monday, Wednesday and Friday of each week, except during July and August. Each class consists of 20 apprentices, making a total of 60, each apprentice receiving two hours instructions a week. The company has fitted up a school-room in its storehouse building, and has supplied tables, benches, blackboards and all the necessary drawing boards, "T" squares and other supplies, excepting the drawing instruments, scales and triangles.

6 The method of instruction is as follows: The boys are required to draw from models and castings. They are first put to work making free hand sketches of wooden blocks of various shapes in order to acquire a facility in representing objects which are afterward laid out to scale on drawing sheets. This is followed by more advanced work which eventually gives the apprentice a thorough knowledge of tools, and enables him with little effort to read, make and work from drawings. Text books are dispensed with, as it is necessary to give instructions as the individual needs of each student require.

7 Typewritten sheets, in blue-print form, are distributed among the students, as a basis of study in connection with the practical work placed before them. These treat of elementary geometrical problems, formulæ, pulley and gear speeds, screw threads and other matters of interest to the student.

8 The question may be asked, "Does it pay the company to do all this for the apprentices; is it not probable that the majority of these young men will leave the service of the company and procure positions elsewhere?" The facts are, that in a district where there is a demand for mechanics it is a difficult matter to retain young men until the completion of their apprenticeship. The situation at our plant, from 1905 to the present date, is as follows: 144 apprentices were on our rolls during that period. 21 resigned after serving one to four months; 8 resigned after four to twelve months service; 8 resigned after serving one year; 6 resigned after serving two years; 6 resigned after serving three years; 6 resigned after completing the apprenticeship, and 18 are in service as machinists, having completed their apprenticeship; 7 were discharged, 7 placed on a probation period of 2 months, and 57 are now in service, time not completed. The boys who served from one to twelve months and then resigned either lived too far from work, were not strong physically, or did not care to learn

the trade. The majority of apprentices remained in service after completing their apprenticeship; and there is no doubt that the knowledge gained by these young men, while attending the apprentice school, has helped them along considerably with their work, and the company certainly has been benefited.

9 By selecting the brighter apprentices, boys who show an interest in their work, and giving them employment in the drawing room for a short period, it is possible to recruit from the shops young men, who, if they will pursue home studies in connection with their work, can eventually fill positions as foremen or designers. This plan is also being followed out by the Central Railroad of New Jersey.

MR. LUTHER D. BURLINGAME In considering the apprenticeship or trade school question there are two distinct objects to be attained; one is the raising up of foremen and managers—those who can carry on the executive work of the shop, and the other is the training of expert workmen who can do a good job and who will be proud of doing that job satisfactorily. One great lack in both the trade school work and the apprenticeship system, as usually carried on, is the tendency to create in the boys the ambition to become foremen only rather than some of them expert workmen of the old type.

2 Mr. Russell's paper shows that the apprenticeship system is not a dead issue, as has so often been pointed out by our journals, for many concerns are taking it up in a systematic way. The works with which I am connected—The Brown and Sharpe Manufacturing Company—has had an apprenticeship system in successful operation for more than fifty years. Our business has been developed on this basis and the men that have been thus trained, have, in a large measure, been a vital factor in our work. We are today however looking toward developing in addition workmen who will be satisfied to become good workmen, not with ambition to become managers, but taking pride in doing a good job and finding their satisfaction in life in being expert machinists.

3 I am glad to see that efforts are being made to give boys who have had a very limited school training a brighter outlook upon life; to make expert workmen of those who would otherwise be only clerks or laborers. Such a development will give a great impetus to our mechanical work. This is where our greatest need is at the present time and where the remedy should be applied.

MR. HENRY GARDNER Mr. Russell's statement of the influence of big-minded, broad-gage instructors receives my hearty endorse-

ment. A bright, energetic shop man, mature enough to be serious and to have the welfare of each boy at heart—preferably a man who has served his apprenticeship in the shop and in the classroom—is the ideal instructor. This man's life work is in the shop, and the whole of his influence is exerted to direct the boy toward the shop as the goal at the end of four years' study.

2 I am not in accord with the policy that makes mechanical drawing "the backbone of the course." Drawing should be emphasized only during a period sufficient to enable the boy to make good working drawings and sketches—perhaps during the first two years—the remaining two years being devoted to problems demonstrating shop practice, such as valve setting, setting driving box shoes and wedges, quartering driving wheels, screw cutting and gearing. Models for studying the Stephenson and Walschaert valve gears might be employed, and methods devised, largely eliminating the drawing, for studying the working principles of the air brake, injector, lubricator, intercepting valve and other important locomotive accessories, all of which are repaired in the shop.

3 It would be beneficial to specialize during the fourth year, after the plan in vogue in some of the leading technical schools.

4 Advantages additional to those already cited, are: The boys are taking more and more responsibility, and the confidence of the foreman in the boys is constantly increasing. Apprentices are chosen to set valves, put up shoes and wedges, make templets and jigs and do many kinds of high-grade work. The gain to the employers from the noticeable increase in ambition, manliness, self-confidence and sense of responsibility cannot be questioned. The apprentice boy of today is undoubtedly the "timber" for the future shop foreman.

DESIGN OF ENGINES FOR THE USE OF HIGHLY SUPERHEATED STEAM

By Max E. R. Tolz, Published in September Proceedings

Mr. H. Emerson It is somewhat ungracious when a member has been kind enough to present to us a table involving as much labor as the one by Mr. Tolz for me to cast doubt on the value of his conclusions. What leads me to do this is that during the last three years I have had charge of the records of over sixteen hundred engines on one of the largest transcontinental railroads. Many persons have suggested various operating economies. Most of them are theoretical rather than practical. Hence, when I see statements to the effect that the use of some particular kind of appliance, the use of some

form of superheater has actually effected a saving in coal, or a saving in water, my past experience leads me to feel skeptical until practical results are shown.

2 Road engines in actual service will be charged on an average with 240 pounds of coal per 1000 ton miles. The same engine, on a measured test, will use 80 pounds of coal per 1000 ton miles. If an economy of 20 per cent is effected in road issues of coal, it must be about 48 pounds or 60 per cent of the coal actually required for steam. This is manifestly impossible.

PROF. F. R. HUTTON It may be of interest to report an experience on an engine with a packless throttle valve and superheated steam. The inventor sought to make a diaphragm valve, the spindle of the valve being attached to a diaphragm of sufficient area so that there would be no resistance from the flexure.

2 The difficulty was found to be that the throttle valve spindle continuously lengthened under the exposure to the superheated steam; so that every once in a while, even if you started out with full adjustment, a time would come when you couldn't get that throttle valve to open because the spindle lengthened and closed the valve. So that while apparently from without it was in the position of being wide open, it was really nearly closed.

MR. H. H. SUPLEE Recently one of the most prominent builders of steam engines in Switzerland informed me his works were about to begin building engines for the use of superheated steam and they found that the Corliss valve gave them trouble.

2 He said he had practically decided that a steam engine for highly superheated steam should be designed with poppet valves, along the general lines of the gas engine and possibly for even higher temperatures as the use of cooling water is not permissible. Metal temperatures of 450 degrees fahr. and higher occur with superheated steam, and this is materially higher than the water-cooled cylinder of a gas engine. On account of the high degree of superheat often desired, the gas engine design may well be taken as a guide for suitable provision for the expansion of steam engine parts exposed to such a high temperature range. Under such high working temperatures the question of the molecular change of metals becomes very important and opens a wide field for investigation.

PROF. C. E. LUCKE As the commercial value of the steam engine, as well as of any other machine, depends more upon the cost side of

the question than upon thermal efficiency, I should like to ask the author of this paper to present some data on how the cost of manufacture of this poppet valve engine would compare with our present standards.

2 I should also like to ask him to state how the cost of maintenance and lubrication would compare with the existing standard, engines, and how the lubricating oil should be specified.

THE SPECIFIC HEAT OF SUPERHEATED STEAM

By Prof. C. C. Thomas, Published in December Proceedings

Prof. C. H. Peabody[1] It gives me great pleasure to express my high appreciation of the importance of the experimental work presented by Professor Thomas to this Society and to the engineering profession in his paper on "The Specific Heat of Superheated Steam."

2 The importance of settling the vexed question of the specific heat of superheated steam is so well understood, and the sufficiency of the methods used by Professor Thomas are so evident from his presentation that it is not necessary to enlarge on the subject. Rather I will proceed at once to show what use I have myself made of his results, more especially as I believe this will put in evidence the advantages that the profession can derive from his labors and the reliance that can be placed on his work.

3 Early in the summer Professor Thomas sent me photographic prints of curves showing results of experiments on the specific heat of superheated steam made under his direction and incorporated in the graduation thesis of Mr. Short. These curves gave the mean specific heats in each instance at a certain pressure, between the temperature at saturation and a series of higher temperatures. For my purposes I desired also to know the specific heat *at* those several points, which properly could be determined from Mr. Short's curves by differentiation. The curves thus obtained were faired by cross-curves which had the effect of distributing accidental error both of experiment and of the graphical operations. A great advantage of this operation was that it gave means of making a direct comparison with the very important investigations by Knoblauch and Jakob recorded in the *Mitteilungen uber Forschungsarbeiten, etc., Heft 36, p. 109.* Fig. 1 shows the result of this method of comparison at the pressure of 100 pounds absolute. The apparent discrepancy is due,

[1]Professor of Engineering, Massachusetts Institute of Technology.

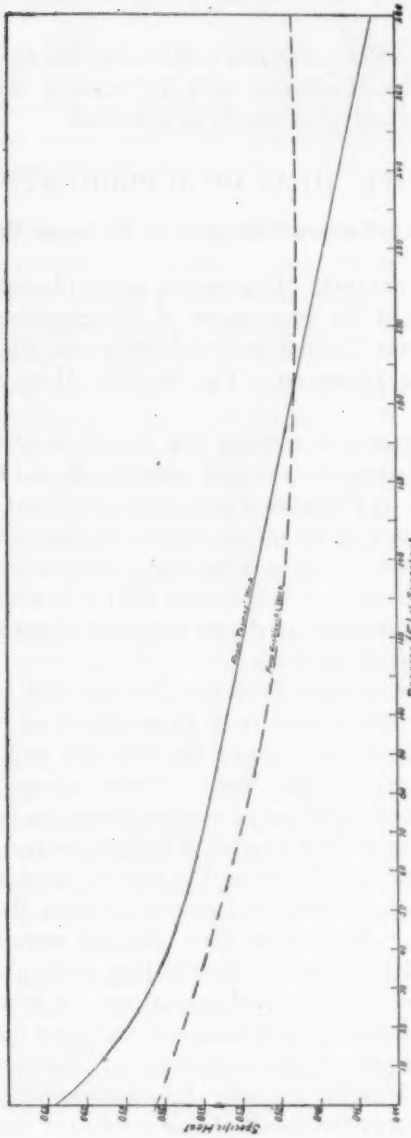

FIG. 1

in part, to the relatively large scale of the ordinates; it will be shown presently that the apparent discrepancy may properly be considered as in reality a good check on the results by two radically different methods.

4 A criticism, favorable or otherwise, of their work would be out of place here, but it may be proper to say that they appeared to have some difficulty in maintaining constant pressures over the very large periods of time required for their experiments, and that the distribution of points on their diagrams appears to show that an allowable latitude in drawing their curves would have made them approach nearer to those I have derived from Professor Thomas's work. It is much to be regretted that their apparatus did not allow them to go above eight atmospheres or about 113 pounds absolute.

5 There are two important properties that may be computed from the specific heat of superheated steam, namely, the heat required to superheat the steam, and the increase of entropy due to superheating. The first may be represented by

$$\int c_p \, dt,$$

and the second by the expression

$$\int \frac{c_p \, dt}{T};$$

here c_p is the variable specific heat, represented by curves like Fig. 1, and T is the absolute temperature. Both of these results were obtained for my purposes by aid of a large integraph which was carefully tested and found to be both delicate and accurate.

6 To get the heat required to superheat the steam it was sufficient to run the instrument over curves like those in Fig. 1, drawn to a large scale. Our diagrams easily gave an accuracy of a single thermal unit. To get the increase of entropy due to superheating, the function $\frac{c_p}{T}$ was computed for a sufficient number of temperatures and a new series of curves was drawn. Running the integraph over these curves gave the desired property.

7 To show the practical effect of the discrepancy between the results obtained by Professor Thomas and by Knoblauch and Jakob, a curve of the nature just described was determined from the tests of the latter at 100 pounds absolute and integrated in the same way. A small section of the two curves is shown in Fig. 2, drawn to a large scale, at the maximum deviation. This maximum deviation is 0.004

of a unit of entropy, the entropy due to superheating from Professor Thomas's work being 0.121; but this increase of entropy in practice is always used in conjunction with the entropy of the liquid and the entropy of vaporization, which quantities at 100 pounds are 0.4743 and 1.1227 respectively; the total increase above freezing point is consequently 1.5970, and it is with this latter quantity that the discrepancy should be compared. Such a comparison shows that the discrepancy amounts to one in four hundred, which must be consid-

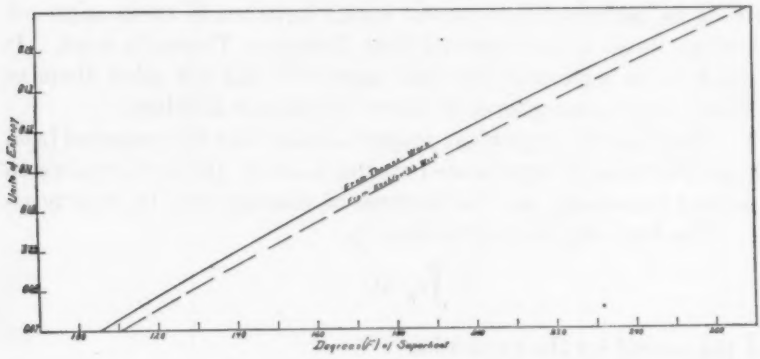

FIG. 2

ered to be eminently satisfactory. It should be specifically stated that I am not attributing such a degree of error to Professor Thomas's work which must be judged by itself, and which needs no commendation from me.

8 If it be permitted, I would like to state the purpose I had in view in my use of Professor Thomas's work, which was the preparation of a temperature-entropy table which should give the properties of steam, both saturated and superheated, at each degree fahrenheit from 80 to 420, and at each hundredth of a unit of entropy.

9 The properties given in the table are:

a *The quality.* For saturated steam this is usually represented by x_1 and is that proportion of the mixture which is steam. For superheated steam it signifies the superheating.

b *The heat contents.* Using r and q to represent the heat of vaporization and the heat of the liquid, and c_p for the specific heat, this property is represented by

$$x\,r + q \quad \text{for saturated steam}$$

$$x\,r + q + \int c_p dt \quad \text{for superheated steam.}$$

c *The specific volume.* This table was made primarily for our own use at the Massachusetts Institute of Technology, especially for teaching turbine design, and it is hoped that it will prove useful to others.

J. A. MOYER Prof. Thomas' values for the mean specific heat of superheated steam at constant pressure, as now reported, agree, in some cases, almost exactly with those of Knoblauch and Jakob. I have prepared typical curves showing comparative values and find for superheats less than 270 degrees fahrenheit, and pressures ranging from 100 pounds per square inch to 200 pounds per square inch, where the specific heat of superheated steam at constant pressure enters as a factor, engineers may adopt, without appreciable error, either set of results. These remarks, it should be noted, are intended to apply only to the mean specific heat values.

2 Marked differences, not so much in actual values as in shape of curves, are observed between the curves of Knoblauch and Jakob, and those given by Professor Thomas above 250 degrees fahr. superheat. Professor Thomas' values are represented by practically straight lines with constantly decreasing values in the region of high superheats, while curves of mean superheat prepared by others, as those by Sugden from Knoblauch and Jakob's results give minimum values at from 200 to 400 degrees fahr. superheat, depending on the pressure. We have no means of knowing definitely which results are the more nearly correct, but as this is a disputed point, referred to by Professor Thomas in his paper, I wish to add something that to me appears to be very significant.

3 I have shown in calculations, published in the London Mechanical Engineer, of August 24, 1907, involving the impulse force of jets of superheated steam and using most recent and reliable data for the *flow* of superheated steam in nozzles, that the specific heat at constant pressure has a minimum value. In other words, this evidence confirms the observations of Knoblauch and Jakob, that:

a Values of the specific heat of superheated steam at constant pressure have a minimum value for any given pressure; and

b That if the temperature is increased beyond that corresponding to the minimum, values of the specific heat are increased.

4 It is also observed that if Professor Thomas' 300 pound line of *true* specific heat is extended in the direction he has drawn it, we

shall have at 600 degrees fahr. of superheat a remarkably low value of about 0.45.

5 For the values of the specific heat of superheated steam at high pressures, the values of Knoblauch and Jakob agree much better with those of other recent observers including Callendar, Linde, and Lorenz than with those of Professor Thomas.

Finally, I may summarize:

a That the results given in this paper may be accepted by engineers generally for pressures from 100 pounds to 200 pounds per square inch without serious error.

b That compared with the results by other experimenters the results for high pressures apparently are not so well established.

c That because very high temperatures and superheats above 270 fahr. were not included in these data, they can scarcely be used to prove that the specific heat does not reach a minimum value, as shown by the very careful work of other experimenters.

POWER SERVICE IN THE FOUNDRY

By A. D. Williams, Jr., Published in October Proceedings

Mr. Frank Richards Mr. Williams' interesting paper challenges remark in one particular. He says: "With a central compressing plant, as generally installed, the use of compressed air requires an expensive transmission line, and, in addition, it is impossible to avoid leakage in the joints."

2 For line piping for compressed air transmission, precisely the same pipes and fittings are used as for steam or water, and it is no more difficult to make joints tight, and to keep them tight, for air than for steam or water. In fact it is much easier to keep air pipes tight than steam pipes, as the same heating and cooling, with their accompanying expansion and contraction stresses, do not occur.

3 It might be well for Mr. Williams to step over to the Pennsylvania Terminal excavation about West Thirty-third Street. He will find there considerable lengths of compressed air pipes running all around the excavation, with branches reaching in various directions to hoists, pumps and rock drills; and if he can find any leaks there, he will do what the writer has not been able to.

4 At the Phillipsburg shops of the Ingersoll-Rand Company all the power transmission is by either electricity or compressed air. There are some miles of compressed air pipes, and various air oper-

ated devices are employed both in the foundry and elsewhere, and the pressure left in the pipes at night is found in them next morning.

5 The quarry of the Cleveland Stone Company at North Amherst, Ohio, has nine or ten miles of compressed air pipes, all the machinery of that extensive quarry being air driven, and there the piping is "bottle tight."

6 Mr. Williams states further that "compressed air pipe lines, as usually constructed, are designed to remain tight only long enough to pass the acceptance test." The compressed air business, just like the other established lines of manufacture represented by hundreds of members of this Society, has grown and has prospered, not by the passing of acceptance tests, but by all-the-year-round efficiency and reliability after acceptance.

7 In this connection it seems to be permissible, if not imperative, to call attention to a record of compressed air practice which is unique. For supplying the compressed air by whose agency the various tunnel enterprises of Greater New York have been carried so nearly to completion, there have been installed, all of them being still in place, eighty air compressors. The combined free air capacities of these compressors amount to 190 000 cubic feet per minute, which volume would be represented by a cube with a side of 57 feet. They develop an aggregate of 40 000 horse power.

8 These compressors, as they were erected, were almost immediately put to work, and if there was any acceptance test in any case the ceremony was generally omitted. The compressors have worked constantly, most of them day and night, and always some on Sundays, at speeds never before recorded, and with life and death dependent upon their maintenance of the working pressures; conditions of unusual difficulty and many of them unforeseen and unprovided for have developed; there have been accidents and delays innumerable in the progress of the work; all these we have heard of, but not one word of any shortcomings of these compressors.

9 The work of building these tunnels, as is well known, was done under the direction and approval of some of the world's most experienced and responsible engineers and by several different contracting companies, but every one of these eighty compressors was built by the same manufacturing company. The acceptance test may be said to have been in the completion of the entire task, and the triumphant accomplishment of this is in sight.

10 Again, we are told that "except in the large sizes, air compressors are steam eaters like steam pumps." The steam driven air

compressor of any size is normally a stationary steam engine with its power applied directly to the work of compression; and for steam consumption and power development it is always comparable upon equal terms with the ordinary stationary engine of the same type. It may have a plain slide valve with suitable lap, it may have an adjustable cut off or it may be a completely automatic engine with Corliss or equivalent valve gear; and we may in every case expect the same economy in the compressor as in the stationary engine. The ordinary steam pump of any size has clearances large and uncertain, but certainly large, and it uses the steam entirely without expansion; so that the pressure at the end of the stroke is as high as the highest. Its piston speed is slow; it is comparable only with itself.

MR. E. H. MUMFORD I think that no one will accuse me of favoring hydraulic power rather than compressed air; I have too many compressed air molding machines in stock that I would like to sell; but the undoubted fact is that a leak in a compressed air system is very subtle, hard to detect, and generally neglected, often becoming serious. I presume many of you have had experience with feeding oil to the air end of an overloaded compressor. It is astonishing how it increases the delivery of leaky valves. If someone would originate a dry air valve for compressors that would work satisfactorily without leakage, the efficiency of a compressor plant would be very much increased.

2 Now, I am not condemning compressed air nor air compressors. They are absolutely essential in a great deal of our work, perhaps in the majority of it.

FOUNDRY CUPOLA AND IRON MIXTURES

BY W. J. KEEP, PUBLISHED IN NOVEMBER PROCEEDINGS

MR. G. R. BRANDON Having had many years experience in the manufacture of the Whiting cupolas and being in constant touch with operators of these cupolas, Mr. Keep's paper has been of especial interest to me. I desire to comment on several points he raises:

2 Cupola linings commonly consist of backing brick next to the shell, blocks 4½ inches or 6 inches thick, forming the inside lining, coming in contact with the heat and having to withstand the abrasive action of the stock in descent from charging door. The blocks are usually of volume equal to about 3 "square" bricks, and prices are practically the same, the volume being considered. In setting lining the work may be accomplished more quickly and cheaply with

blocks; and, on account of the fewer joints exposed to the action of the heat, inner linings last longer when composed of blocks than of the same quality of "square" and arch brick.

3 The usual instructions to operators of cupolas are to maintain inside walls of linings vertical and cylindrical in section from bottom plate to charging door, and to pick out slag attached to brick before each heat and apply daubing mixture. The simplicity of this procedure is its greatest recommendation; but, as safety from "hang-ups" is assured if cupola is operated properly in other respects, the very doubtful benefit derived from reduced bosh and enlarged melting zone may be disregarded.

4 Twyers may be located so that any suitable quantity of molten metal may be accumulated in the cupola before tapping. In the converter processes for steel castings iron is first melted in cupolas and it is usual to collect the entire amount for a charge in the cupola before tapping out, the twyers being set to permit this accumulation.

5 The lower the twyers, the less the amount of fuel on the bed and the greater economy. It must be remembered, however, that fuel in bed serves the purpose of heating up the cupola and sufficient must be charged to accomplish this result, whatever the height of twyers.

6 The standard twyers of Whiting cupola are flaring, the opening at the inside of lining being wide, horizontally, and comparatively narrow, vertically. The adjacent twyers in the lower row almost meet practically forming a complete annular inlet.

7 One frequent cause of "run-outs" through bottom doors is the use of overhanging linings. The sand of the bottom not being tucked properly under the projecting lining at all points, the molten metal cuts through in a weak spot. In this emergency a tap hole should be opened, all molten metal drained out and a stream of water directed on the hole through the bottom to "freeze it" Plugging the hole with clay will allow the completion of the heat.

8 For cupolas with 84 inch shell, and larger, a mechanical charging machine can be used and the labor of charging greatly reduced. Records show that two men with this machine can charge a cupola melting 18 to 20 tons per hour, whereas, without the machine, five or six men would have been required.

9 I have never known of records of actual operation, showing as high a ratio of iron to fuel as 18 to 1. This would be practically impossible with our wheels. Mixtures for car wheels are low in silicon and, consequently, the molten metal lacks fluidity and must be very hot when tapped, and poured quickly. Steel is now gen-

erally used in car wheel mixtures and this requires more coke. Pigs and large scrap are generally considered to require more fuel than broken pigs and smaller scrap. We have a record covering eleven months operation in which over 13 000 tons were melted for car castings, the ratio of iron to fuel being to 10.31 to 1. These results have always been considered most excellent.

THE FOUNDRY DEPARTMENT AND THE DEPARTMENT OF ENGINEERING DESIGN

By W. A. Bole, Published in September Proceedings

Mr. A. B. Carhart I want to ask the effect of increasing the size of the fillet from the flange to the main body portion upon the castings of iron valve-bodies weighing from 100 to 200 pounds. I find there is a difference of opinion between the foundrymen and the pattern designers as to the desirability of increasing and enlarging the fillet to leave a larger body of the metal at the point where the body gradually tapers off into the flange. The foundrymen claim, as in this paper, that too large a fillet is undesirable. Can anyone confirm our experience, that too great a body of metal in that part induces a porous condition which tends to weaken the structure?

Edward N. Trump My experience in the designing of many large castings, especially rings and bases of large apparatus, ten to thirteen feet in diameter, has convinced me that it is especially important to keep very even sections of metal; that wherever there is a body that is a little larger than the rest it does not cool quite so fast and from that part the metal is drawn to the other parts.

2 Recently in the case of a flange some ten feet in diameter, the designer wanted to get a little greater distance between the two heads on a ten foot cross, the heads being for tubes, and he thickened the metal up about half an inch at the flange and also put in quite a large fillet. That seemed to keep the flange from cooling. When the flange came to be drilled, for holes around the outside edge, it was found that every hole had an opening in its center which communicated with the inside. The consequence was that they all had to be bushed in order to keep them tight. I know of the case of a flange where, although the outside skin showed no apparent rupture in any way, yet when it was broken open it was found to have holes of this character.

We have found in other cases where we put in an additional section on a small part which cooled more slowly than the rest that

it was sure to give us trouble; we always had empty spaces caused by the shrinkage.

MR. A. D. WILLIAMS In the ingot buggies used in steel mills, where the ingots are cast upon cars, it has been found that unless the section of metal was kept uniform the buggies often gave out under the stripper, the top of the buggy being pushed down on the axles. The result of experiences of this kind has been to modify the early designs, big fillets were cut out and the edges of the car are rounded over to form the sides, the thickness being kept uniform throughout.

2 We used to employ a great many gear wheels, and had a great deal of trouble from shrinkage over the arms where they joined the rim. These defects were expensive, as they were rarely discovered until the wheel had been partially finished. The difficulty was overcome by putting a gate or sinking head on the rim at each arm. After this was done there was comparatively little trouble. The foundrymen who did the work for us tried a great many experiments and different mixtures of iron before they discovered the simple remedy for the trouble.

MOLDING SAND

BY A. E, OUTERBRIDGE, PUBLISHED IN OCTOBER PROCEEDINGS

MR. E. H. MUMFORD As we all know, the mere handling of molding sand has a strange effect upon it. There are two classes of treatment, which, while not affecting its porosity, will vastly increase its strength. One is putting it through a reciprocating riddle, turning it over with a shovel, or otherwise throwing it about. The alternative treatment is rubbing the alumina in the sand into the silica.

2 In one of the classes of treatment involving the use of the scraper conveyor there enters another curious effect. In the scraper conveyor, turning the sand over always in one direction, there is a tendency to roll the particles of alumina up into balls, much as a snow ball is rolled along, gathering more snow; but under this treatment it has been common experience that more or less damage is done, as the speed of the conveyor is greater or less, the tendency being to cause the alumina to gather apart from the rest of the sand and the silica particles to be wiped clean of their coating of alumina, the result being that while you have all the constituents of a good strong sand, it has lost its bond and is practically worthless for many kinds of molding.

3 There is no question but that the Sellers centrifugal mixer is

better than any other method of impacting or turning over and throwing together.

4 The experiments of Mr. Ronceray, which would doubtless prove of interest to members of the Society, consist of putting into an ordinary heap of sand a certain percentage of pure white silica sand, making the heap so rotten that it would not mold anything, and then rolling or rubbing that mass of sand on a plate with a hand roller. He takes six samples and gives each two minutes rubbing. After rubbing thus, the color first of the sample taken is gray; the next sample is less gray, and, finally, when you get to the sixth sample, it is practically the same color as the original heap. Every single crystal of silica has been coated with the dark alumina of the foundry sand. So, after twelve minutes rubbing by hand with an iron roller on an iron plate, the last sample is even darker and stronger than the original heap from which it was taken.

5 In our molding machine demonstration plant in Philadelphia we use ordinary heap sand for our demonstrations, and, as it never feels the heat of molten iron, it has been almost impossible to keep this sand weak enough to be a fair sample of molding sand. We have to keep adding silica sand to it.

PATTERNS FOR REPETITION WORK

By E. H. Berry, Published in Mid-October Proceedings

Mr. Robert Shirley I am surprised at the very small variation in pattern dimensions allowed by Mr. Berry, in some cases only 0.001 of an inch. It has been my experience that an operator on a machine, where the molds had to be rammed by hand, could make a very perceptible difference in the size of the finished castings by ramming the molds soft. The resulting casting, instead of shrinking, being considerably larger than the pattern.

2 A remiss engineer has caused us considerable trouble in this connection by dropping his air pressure, so that a power ramming machine intended to work under 80 pounds of air was actually working under 40, the results being soft molds, and castings considerably larger than the pattern. These are discrepancies which cannot be taken care of in either the drafting room or pattern shop.

Mr. E. H. Mumford Mr. Berry, owing probably to exceptional care and skill, as evidenced in this paper, took a set of very difficult patterns and absolutely new molding machines and installed them

in a foundry where the labor conditions were especially adverse, and made a complete success of the installation.

2 Those of us who know how difficult a thing that is to do, and how many times the attempt meets with failure will appreciate what this paper of Mr. Berry's stands for.

3 The author speaks of the advantage of a small size of flask. The particular advantage of this outside of convenience in handling, is the elimination of the risk of sag. If the cope surface sags so that the two surfaces of the mold meet at or near the center they will surely creep out of match and cause all kind of queer distortions generally toward the outside edges of the mold joint.

4 It is stated that the flask must be deeper than the desired depth of the mold. That is true in ramming a bottom-board into the mold itself. It is not necessary, where a sand frame holding the excess of unrammed sand is placed over the flask. Mr. Berry illustrates what is to me a very interesting fact. I have found but one man in this country who has made the departure of putting a pattern in the cope, and a pattern in the drag and bringing their corners together. The French practice, I understand has been for years to bring castings placed as these are in the mold into actual contact, so that the corners actually touch. It may seem paradoxical to some; and you will notice in the figure that Mr. Berry has carefully kept his casting about one-sixth of the spacing apart. If you could save this 16 per cent you would gain so much more room in your flask.

5 At the last foundry exhibition in Philadelphia, in May, a large number of castings was exhibited, made on the French molding machine in which the contact was absolute, and the castings after being poured and cooled adhered to one another until they were broken apart in the mill. The commercial advantage of putting castings edge to edge in a mold is very material.

6 In this paper there is no mention made of a solid cast match plate, and it is surprising to discover that there are foundrymen who have never seen a solid cast match plate made in its simplest form. It is not correct to say that you must have a joint surface in your plate that is susceptible of being machined or you must use "open carding." It is possible and it is current practice, to take the ordinary run of patterns and make a mold in the usual way, and then raise the cope the thickness of the plate you wish to make, closing the cope on a check against which the edges of the match plate will be run of desired shape and dimensions, forming what is virtually a fin in the casting the thickness of the match-plate desired. The only objection to the method is that, if the plate is heavy relative to the casting,

the additional volume of the metal tends to produce a slightly rougher surface. There is a slight burring of the corners especially on the cope side of the plate, and, in match-plates, particularly those made of white metal or aluminum, or bronze, this may be eliminated by running a tool around the corners. There is an advantage in being able to do this tooling; by it you can make the mold joint firmer by taking metal out or burring down the surface at the corner.

7 This matter of the springing of the match board, or the bottom board, is one of great importance; but there are many other conditions beside the mere distribution of the pressure of the sand which tend to complicate the problem.

8 One of the cuts shows a gate in both parts of the mold. In our experience it is not good practice to put such a gate in, unless great care is taken to match it. As a rule, such care is not given and a slight mis-matching leads to an unsupported corner of sand, which is almost sure to wash and give trouble by carrying dirt into the molding.

9 In Par. 85, there is a subtle allusion to a very valuable fact; namely, that it is not always machined or finely finished patterns which are the most perfect. There is no better surface for duplicating a casting than one which approximates that of the casting which you wish to produce, and excessive or over zealous finishing often loses a needed shape or thickness.

10 Not long ago I was in a foundry where the stripping plates were of solid iron (no babbitted edges), and the patterns in them were finished like parts of a gun lock. The manager remarked with pride, that there was nothing so cheap as money. Yet, in patterns which have cost so much, there is a strong temptation to save the pattern even after a careless finisher has cut too deep somewhere or rounded a corner which had better been left square.

A HIGH SPEED ELEVATOR

By Charles R. Pratt, Published in October Proceedings

Mr. William H. Bryan The most serious objection to the traction type of elevator is the extremely large motor required to give the necessary power at the very low speed to which it is limited by direct connection to the traction sheave. This increases its first cost, and its weight, the latter an important matter when the machine is placed over-head, the location now generally preferred. Lower efficiency and greater space required are further objections. Any design therefore, which permits higher rotative speed for sheave and motor would appear to be of decided value. The speed of car

fixes the peripheral speed of sheave, and the diameter of the latter must be large enough to insure satisfactory adhesion and life of cable. Has the experiment been tried of using a greater number of smaller cables running over smaller sheaves? For instance; the example cited by the author (Par. 2) shows a sheave 40 inches diameter, speed 57 r. p. m. Presumably the cables are $\frac{5}{8}$ inch diameter. Four $\frac{5}{16}$ cables are equivalent to one $\frac{5}{8}$, and will give satisfactory results over a 12 inch sheave, permitting the motor speed to be increased $3\frac{1}{3}$ times, or to 190. Why not use the smaller cables, and put in four times as many of them? The same automatic tension adjusting scheme could be used as is now so successfully employed. In such a case the breaking or renewing of a single cable would be a matter of minor importance.

2 There would seem to be no objection to widening the face of the sheave to admit the increased number of cables. If greater adhesion is desired, so as to do the required work with a single half wrap, thus narrowing the face of the sheave and doing away with the idler sheave, could not the gripping *V* groove, so successful in Manila rope transmission, be employed? Iron against iron would of course cause too rapid crystallization of the cable, but the grooves could be made with the usual wood or rubber facing. These of course would wear and need renewal. Furthermore, very nice design and adjustment would be necessary in order to insure proper adhesion when needed, and at the same time permit slipping when the car or counterweights land on the buffers. Another method of increasing cable adhesion is by magnets, which have been used where one of the cars is intended for occasional use with extra heavy weights, such as safes.

3 It may also be inquired whether the advantages of higher motor speed might not be secured by chain drive motor from shaft to traction sheave. This device has very high mechanical efficiency.

4 The principle of safe normal limit stops by loss of cable tension when car or counterweight rests on buffers, is not confined to gearless traction machines, but is applicable to the ordinary type of geared machine and many such plants have been installed.

5 It would seem that some slippage of cables is unavoidable in all traction machines. This, and the necessity of using sheaves of minimum diameter, tend to shorten the life of the cables.

6 The author's proposed additional control by substituting for the brake a miniature worm gear of low pitch driven by an independent motor in speed synchronism with main motor, appears to be an excellent arrangement. It would seem to make such an elevator as safe as any elevator supported by cables can be made. Has it ever been

tried? There would appear to be some chance for friction and wear and tear, if the motors did not synchronize perfectly. The cost would probably be increased somewhat, as the additional parts would amount to more than would be saved by the omission of the brake sheave. Neither would it seem reasonable that its current consumption should be materially, if any, less. It would be interesting to know just what performance in kilowatt hours per car mile would be expected. In this respect the standard form of traction elevator has much to commend it.

7 While the author's plan involves nothing experimental in itself, the combination is unique. Unexpected difficulties may arise in practice, and it is hoped that Mr. Pratt will put the device into actual experimental service as soon as possible. Some of the possible difficulties are well pointed out by Mr. Place in the November Proceedings.

8 It does not appear that trouble need be anticipated from a too sudden stop in case the controlling motor failed on a down trip. As this would be the ordinary and regular method of stopping, the original adjustments would have to be made to suit. Should the hoisting motor still be taking current its circuit breaker would at once open. Old types of steam machines were made with low pitch gears which locked the car when stopped, and which were provided with small fly-wheels for bringing the car gradually to rest.

MR. W. F. HENDRY The elevator apparatus described by Mr. Pratt is extremely ingenious and interesting, the requirements apparently being fulfilled in a manner quite worthy of the inventor of the screw machine.

2 The arrangement as described is noteworthy for reliability and simplicity, but being intended apparently merely as a suggestion, the paper is quite brief and leaves considerable to our imagination. There are several points concerning which a more elaborate description would doubtless be of interest to the members.

3 For example, in Par. 15, it is proposed to use a motor of comparatively small size to secure, through the non-reversible worm gear, the desired speed regulation of the car. The speed of this "controlling" motor will be variable through as wide a range as practicable by means of resistance introduced in the field circuit. Such motors as ordinarily constructed may be designed for a maximum speed three times the minimum. A motor built with auxiliary commutating poles, and with a low horse power output per pound might be designed for a variation of 6 to 1.

4 If therefore the maximum speed of the car is 600 feet per minute, the lowest speed at which the car will be under control of the operator will be 100 feet per minute. When making a landing he would therefore, after having reduced speed to this figure, bring his car switch lever to the middle or zero position, thereby, through suitable magnetic devices, opening the circuits of both motors. The car will then continue to move at a constantly decreasing speed until it finally stops even with the landing.

5 It seems probable that to secure this ideal retardation by means of a worm gear driven backward, considerable experimenting will be necessary in order to obtain a gear which will allow a reasonable length of run, and yet eventually lock.

6 Under uniform conditions of torque and lubrication this might not be difficult, but the former varies from positive to negative and attains a value of several hundred pounds in each direction, which condition makes the problem quite interesting.

7 It might be suggested that armature resistance would reduce the speed of the controlling motor, but it should be kept in mind that while the car is traveling up with maximum load, the motor will be taking full load current from the line, and when going down this current will become infinitesimal, so that a resistance to affect the desired result would be somewhat cumbersome.

8 Another point which might be mentioned refers to the omission of any description concerning the stopping of the car. Par. 23 tells us how it is started and Par. 20 *C* states that the controlling motor insures a perfectly smooth retardation in stopping.

9 If it be supposed that the speed of the hoisting motor is reduced from 57 revolutions per minute to 10 revolutions per minute by a corresponding reduction of control motor speed, the question immediately arises as to the speed at which the circuit of the former is opened.

10 If the hoisting motor is disconnected too soon, the load thrown on the control motor will blow its fuse, while if disconnected too late, t will blow its own fuse.

11 A very nice adjustment is indicated especially in view of the variable conditions as to amount and direction of the torque.

12 Another question arises as to the details of speed control. If the simplicity is to be retained, pilot motor, and similar complicated controllers are to be avoided, which means that the control motor shunt field rheostat will be located in the car and practically form part of the car switch. All who have operated elevators know to their sorrow how short is the life of a traveling cable; in fact they are usually installed with one more wire than actually necessary in order to have a spare because it frequently happens that a wire will

break in the first few weeks of use, though the others may last a year or so.

13 In this arrangement the shunt field wires being in the traveling cable, the continuity of the circuit is in constant jeopardy. Should this circuit be interrupted, the control motor would attain under certain conditions, almost an infinite speed. If the car was on the down trip with full load, the action would be similar to the newspaper stories mentioned by the author. When the operator finally realized that the car was running away, and brought his car switch to the stop position causing the main circuit control magnets to disconnect the hoisting and control motors from the line, the car may easily have attained a speed of 1000 feet per minute and the practicability of retarding and stopping the car, by the means described, without discomfort to passengers would be tried to the limit.

14 It may be thought that the fuse of the controlling motor would blow if the shunt field circuit was interrupted, this however will not happen to this type of motor, if it is running free, or with a very light load, which would be the case with the circumstances under consideration. Neither would the series winding have any appreciable effect as the current passing through it would be far less than necessary to provide sufficient flux to reduce the speed.

15 The author in closing verbally states that safety of life and limb should not depend upon electric circuits, magnets, etc. and thus implies that the controller for this elevator will be a comparatively simple affair, and that continuity of any circuit will not be relied upon to prevent accident.

16 Under the conditions mentioned above, however, the only means of stopping the car would be the dynamic action of the main motor, either by delivering current to the line or to a local circuit of resistance sufficiently large to dissipate the energy. In either case, the circuit would include magnetic switches, fuses, resistance etc. which the author recognizes as unreliable devices. These and other minor problems are in no sense insurmountable, but the solution thereof must be carefully considered, in order that the simplicity, so attractive in the paper, be retained in the actual machine.

MR. THOMAS E. BROWN The gearless traction drive elevator discussed by the author in his paper is, we believe, the best form of high speed electric passenger elevator yet devised. It has all the elements of safety and perfection of control of the hydraulic elevator, and is superior to it in that it maintains high acceleration and high speed with loads closely approaching the maximum.

2 This elevator was described by the writer in a paper read before the International Engineering Congress at St. Louis in 1904. In that paper the writer said of it that it is "expected to be used generally in the future for high lifts and high speeds," and we think this expectation is rapidly being realized.

3 The machine in its principles is not new, the so called "traction drive" being that commonly used with cable railways, and used by the writer on several mountain railways. This form of drive was patented by Mr. George H. Reynolds in 1886, and the direct attachment of the motor to the driving sheave was shown by A. L. Duwelius in a patent issued in 1897, and the present machine is the combination of the direct motor of Duwelius with the "traction drive" of Reynolds.

4 Numbers of machines with friction rope drives have been in operation for years, both in this country and Europe, but in all, as far as the writer knows, high speed motors were used with reduction gearing, or non-retarding rigging, as covered by the Duwelius patents of the Otis Elevator Company, and the novelty of the present machine lies in the extremely slow speed of the motor and entire absence of gearing.

5 This combination was proposed by the writer several years ago, but met with no encouragement from electrical engineers, as it was believed that the slow speed motor would be extremely large and costly, and of very low efficiency.

6 Experience has shown, however, that when designed and constructed for this slow speed the efficiency is about as high as that of the high speed motors designed for elevator service, and high efficiency is maintained from about one-quarter to full load, or over nearly the whole range of loadings occurring in the variable elevator service.

7 The size and cost also are not prohibitive. The size of the motor is offset by the reduction in size of the drum, and the cost of the motor is offset to some extent by the saving in the gearing. The first cost of the elevator is greater than that of ordinary drum elevators, but when it is considered that the elevators now being constructed for the Metropolitan Life Tower will lift 3000 pounds in the car at a speed of 600 feet per minute, and will accelerate the total moving mass of about 20 000 pounds to this speed in about four seconds, it would seem doubtful whether a geared machine of the ordinary type to do the same duty could be produced at any less cost, and it is quite certain that any type of hydraulic machine of the same rise and duty would be much more expensive.

8 The writer thoroughly agrees with the author in the merits he

described as inherent in this type of machine. The sufficiency of the friction cable drive hardly admits of discussion, as it has been proved by many years of use. The writer has installed a plant of three elevators having but 270 degrees of contact, and finds the tractive force sufficient for ordinary passenger elevator service.

9 We can not agree with the author that the traction is greatest with well worn and thoroughly lubricated ropes, as our own experiments indicate the contrary, but the difference between new dry, and old thoroughly lubricated ropes is less than 10 per cent; hence for all practical purposes the condition of the cables does not materially affect the traction.

10 The safety of the traction drive elevator is essentially greater than that of any other existing type for the following reasons:

a It admits of the use of a large number of ropes of which the simultaneous breakage is well nigh impossible, and may therefore be considered as entirely without danger of a "free fall."

b It is free from the greatest of all elevator dangers, namely, overwinding.

c It has the best of all speed regulators, namely, the shunt wound motor.

11 In addition to these points of safety inherent in the design and construction it is provided with:

a A double brake held off by the current, and only used in normal operation to hold the machine when not in motion.

b A speed governor controlling the motor.

c A hand brake in the car under the control of the operator.

d At least one set of efficient safety devices operated by a speed governor.

e Also the usual electric terminal stops, and in addition to these, long stroke buffers, under the car and counterweight, capable of stopping the elevator at the greatest speed it can reach, by gravity, either terminal.

12 It would seem quite impossible that all of these safety elements could fail simultaneously; but let us assume for the sake of argument, that all the electric devices and the motor fail, and the two brakes on the machine fail, then under the worst condition which can occur in the cases cited by the author the car can accelerate by gravity at about 1.6 feet per second (one-twentieth of the acceleration of gravity); or the condition is the same as that of an ordinary trolley car on a 5 per cent grade.

13 We are perfectly content to ride in a trolley car with no other provision for safety, in the event of failure of the electric devices, than brakes controlled by the motorman, and no efficient terminal stops at the bottom of the grade. Then how much more content we should be in an elevator car under the same conditions with all the automatic safeties noted in addition to the brakes, and most efficient terminal stops and buffers at the end of the run.

14 It would seem, therefore, that the worm gear and extra motor and control proposed by the author would be a complication added on the plea of safety to an already essentially safe machine, and tend to defeat the very objects of its production, namely, perfection of control, rapid service, simplicity and high efficiency.

15 The writer thinks there will be some practical difficulties in the design of the proposed worm gear. The author's patent shows the gear somewhat larger than the driving drum. If it were the same diameter as the driving drum, the normal peripheral speed of which must be 600 feet per minute, the pitch line speed of the worm of 5 degrees angle must be about 6700 feet per minute; rather a high speed, involving either a very large diameter of worm, or a very high motor speed.

16 Thus for 1000 revolutions of motor, the pitch diameter of worm would be almost two feet, or conversely for a reasonable sized worm, say six inches pitch line diameter, the motor revolutions would be about 4000.

17 Unless we are assured of absolute synchronism under all variations of acceleration and speed, such a fast moving worm would be subjected to considerable frictional resistance, involving loss in efficiency, and the motor could not well be of negligible size, as it must be capable of overcoming the greatest pressure that may be brought upon the worm under any condition. It would seem that the acceleration and retardation of such a high speed motor would tend to lengthen the starting and stopping distance of the elevator rather than shorten this distance, and detract from one of the greatest merit of the elevator, namely, active and rapid service.

18 It is difficult to see how the author's device can improve the almost uniform acceleration of 2.5 feet per second already accomplished by this machine.

19 There are many cases of two motors working together, but in all such cases where worms are used, they are of long pitch, and the motors do nearly equal work and synchronize mechanically. It would seem quite a different matter to synchronize two motors; one under variable loads, positive and negative, and the other under no

load, and while the author suggests this, he does not give the slightest hint in his paper how it is to be accomplished.

20 It should also be considered whether such a device may not introduce elements of danger, such as the possibility of locking of the gears while in rapid motion and it is quite certain that a short-circuit of the motor would be destructive to the machine. The writer has experienced the destruction of a double motor machine by the short-circuiting of one of the motors.

21 In the writer's opinion all the merits enumerated in Par. 22 of the paper exist in the elevator as it is now designed and constructed, and it will not be improved by the addition of the proposed worm gear device.

22 In the limited time I have I will not attempt to read the written discussion that I have prepared, but will simply call attention to a few of the points referred to. Mr. Matthews has given us a little outline of the history of the traction drive elevator, in which he showed us the machine in Fig. 2 which was produced by Mr. Reedy. Mr. George H. Reynolds in 1886, that is 22 years ago or at about the same time this one was produced, produced a traction drive elevator which is practically the same as that we use today, with the exception that instead of the motor driving the drum direct, it drove it through the medium of a worm gear; that is to say, it was essentially the same machine Mr. Pratt has shown us, if you remove the large motor and make the controlling motor do the driving.

23 The principal novelty of the traction elevator of today, is the attachment of the large slow speed motor direct on the axle without the intervention of any gearing.

24 Much stress has been laid by the other speakers on the question of safety. There can be no doubt that as high a degree of safety as can practically be obtained is essential in elevator service as well as in all means of transportation, but we must not forget that an elevator, like a locomotive, a steamboat, or a trolley car, has certain functions to perform, and while it must be made as reasonably safe as such service will permit, any attachment which you put upon it which cuts down that service, in other words impairs its usefulness for the purpose intended, certainly cannot be advantageous. Absolute safety can only be attained when motion is entirely prevented.

25 In discussing this machine, several have talked about its liability to run down. True; so also can a locomotive run away, a trolley car can run down a hill. A trolley car on a 5 per cent grade is exactly in the same condition as this elevator, with all its electric devices and mechanical controls destroyed. Take for instance

the case which Mr. Pratt cites of the Metropolitan Life Tower, the acceleration under the worst conditions would be 1.6 feet per second. A little calculation will show that a trolley car on a 5 per cent grade would be the same. Now under those conditions, if we take away the control of the operator, cut off the current, destroy the brake, cut out all the safety devices, it can only reach the bottom at the speed due to a 1.6 feet per second acceleration. At the bottom of the shaft there are placed oil buffers of a stroke proportionate to the rise, which can readily stop the car without injury to the passengers, at the greatest speed at which it could reach the bottom. The writer has run down onto such buffers at a speed of 16 feet per second without serious shock or even inconvenience, and believes that even at double that speed no serious injury would result. This is the intrinsic condition of such an elevator. Why then put on a worm gear arrangement such as Mr. Pratt suggests which can not improve the machine in any way? The machine is already provided with all of the usual safeties of other elevators, and a hand brake by which the operator can stop the car at will in addition to the usual controlling apparatus. It therefore seems to me that any further additions to a machine the whole idea of which is simplicity, certainly cannot tend to improve it. We must also consider that an elevator is a machine which has to perform a service. That is to say, it has to carry a maximum number of people in a given time through certain distances in a building and must stop and start quickly without loss of time from floor to floor, therefore the acceleration must be extremely rapid, and the retardation equally rapid. It seems to me these functions will be interfered with by the worm gear which Mr. Pratt proposes. The shunt wound motor, that is the main drive motor, will have a speed variation between a full maximum load positive and a full minimum load negative, and it is difficult to imagine that it will control much within 10 per cent. I fail to see how the smaller motor can determine for itself just which of these conditions it was to meet and therefore it seems to me the synchronism will be an extremely difficult matter, and without synchronism the machine must be very wasteful.

MR. E. S. MATTHEWS Under this title Mr. Pratt invites our attention to an electric wheel and axle friction cable drive elevator which has been called the gearless traction electric elevator and to a device which he advocates attaching thereto for the purpose of improving it generally and particularly for rendering it safer.

2 The friction cable drive has been well known in cable railway work, mining and blast furnace hoists, and, to a limited extent, in

elevator work; but until recently it has not been extensively employed in high grade passenger elevator construction. There is, however, no reason why it should not be so employed under proper conditions.

3 It is interesting to note some of the earlier types of this friction drive elevator, and Fig. 1 shows a form of factory elevator machine driven by belt in which the friction cable drive was employed a quarter of a century ago, in exactly the same manner as in the traction elevator of today. This machine was usually located as shown in the sketch, in some story of the building (not over the hatchway, as is now usual with the traction elevator), and while the lifting end of

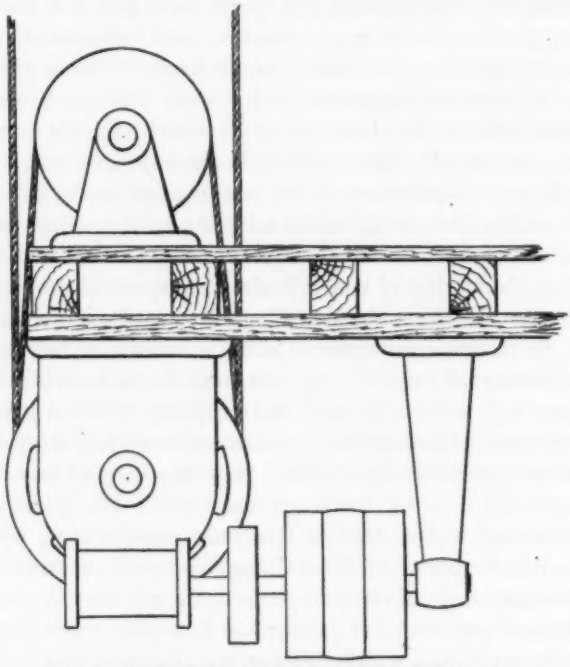

FIG. 1 THE FRICTION DRIVE OF 25 YEARS AGO

the cables passed up the hatchway to the overhead sheaves, the counterweight end, passing up through the floors of the factory near the hatchway (as shown), as this was not considered objectionable in factory construction.

4 Fig. 2 shows a sketch of a steam direct elevator machine which employed the friction cable drive in a little different form, utilizing about 270 degrees of arc contact, and this machine is particularly interesting at this time as it also employed a direct wheel and axle steam power drive, a steam dynamic brake and a steam releasing

friction brake, or exactly the same power driving and controlling devices which are now employed on the gearless traction elevator with the mere substitution of the force of electricity for that of steam. This elevator was constructed by Henry J. Reedy, of Cincinnati; Ohio, a man of more than ordinary originality and ingenuity in mechanical contrivance and was successful in every respect except that the oscillating cylinder mechanism proved defective.

5 The Crane steam direct elevator employed the steam dynamic brake aided by the friction of the worm gear and the engine, in stopping and holding its load.

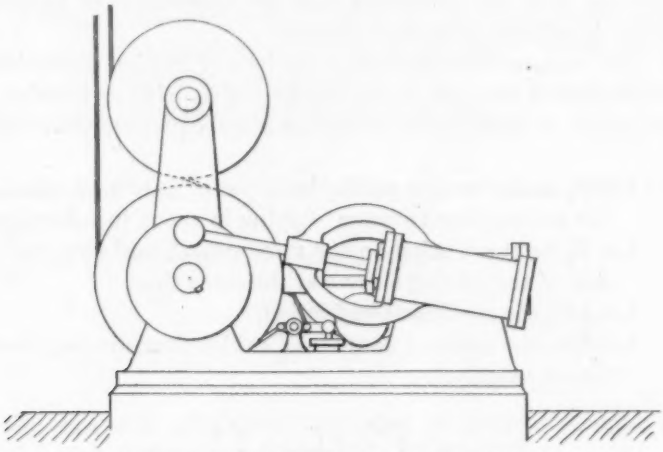

FIG. 2 REEDY STEAM DIRECT ELEVATOR

6 It is a marked peculiarity of the elevator industry that as soon as a new type of machine is brought prominently forward, many arguments are at once discovered in its favor, and they are strenuously advanced by its advocates possibly without mature consideration.

7 We have seen this in the case of the plunger elevator which we discussed about a year ago.

8 Paragraph five of Mr. Pratt's paper seems to the writer to be of this nature. It reads as follows:

"Experiments made by the author on this form of traction rope drive, using iron wire hoisting ropes running in smooth round grooves in the traction sheave, with from 1½ to 7½ half traction turns, demonstrate that the least traction obtained is with new dry ropes on new dry grooves, and that after considerable running there is not 5 per cent difference in traction between a dry rope and a rope flooded with any kind of lubrication. This establishes the fact that if this elevator will handle its full load when it is first started with new ropes, it will always handle its full load safely."

9 These experiments, if accurate, also seem to establish the fact that the coefficient of friction between metal surfaces dry and amply lubricated is practically the same, which conclusion is, of course, untenable.

10 Further, the results, as stated do not agree with the experience of the writer or that of the Trenton Iron Company, as quoted in Kent's Handbook, or with well known determinations of the coefficient of friction.

11 The Trenton Iron Company gives for the coefficient of friction of wire rope on a grooved iron drum 0.120 when dry, and 0.070 when greasy; and adds the statement that the importance of keeping the ropes dry is evident from these figures.

12 The manner in which the coefficient of friction enters into the determination of the pull of the friction cable drive or traction, as it is now called, is shown from the fundamental equations governing the case.

Let T_1 be the tension on the least pulled cables on one side of the driving sheave when slipping is about to take place.

Let T_2 be the tension on the most pulled cables on the other side of the driving sheave at the same time.

Let μ be the coefficient of friction.

Let θ be the angle of contact of cables over driving sheave in circular measure.

Then

$$\int_{T_1}^{T_2} \frac{dT}{T} = \mu \int_0^{\theta} d\theta \qquad [1]$$

or

$$hyp.log \frac{T_2}{T_1} = \mu\theta \qquad [2]$$

or

$$\frac{T_2}{T_1} = \varepsilon^{\mu\theta} \qquad [3]$$

when ε = the base of the system of natural logarithms.

13 We thus see that the coefficient of friction enters into the determination of the traction as an exponential function, thus strongly affecting the result.

14 It is sometimes stated that the rigidity of the wire cables is so great as to seriously modify the theoretical considerations above advanced, and at a superficial glance such might seem to be the case.

15 We will find, however, that under the conditions of the problem as it exists in practice, this rigidity has but slight effect and may be practically neglected.

Let M = the bending moment producing curvature around the driving sheave.

Let R = the radius of the driving sheave.

Let I = the moment of inertia of a single wire of the cable.

Let T = the tension applied to the wire to produce the curvature required.

Let E = the modulus of elasticity for wire in wire rope with the twist employed in this construction.

Let p = the pressure per unit length of arc required to produce the required curvature at the point where the curvature is a maximum.

Let n = the number of wires in the wire rope.

Then since $pR = T$, $p = \frac{T}{R}$ and $M = \frac{T}{2R}$ and remembering that $M = \frac{EI}{R}$ we have, examining a single wire,

$$\frac{T}{2R} = \frac{EI}{R} \qquad [4]$$

or in the case of a wire rope 0.75 inches in diameter, composed of wires of 0.05 inch diameter, where E is 15 000 000 a special value given by Rankine for use in wire rope computations, and which the writer considers practically correct we find $T = 9.206$ pounds. With wire rope 0.625 in diameter composed of wires 0.045 inch in diameter we find $T = 6.039$ pounds.

16 These ropes have six strands of 19 wires each, a total of 114 wires; we thus ascertain that when carrying loads of 1050 and 688 pounds respectively $\frac{3}{4}$ inch and $\frac{5}{8}$ inch wire cables will truly conform to the curvature of the driving sheave, and exercise upon it the proper pressure due to the tension upon them, except for a unit distance of arc as they leave the wheel where they become tangent to its circumference just that much earlier than a perfectly flexible band would do.

17 When thus operating the $\frac{3}{4}$ inch cable is working under a factor of safety of 18 and the $\frac{5}{8}$ inch cable under a factor of safety of 25.

18 With the 40 inch diameter driving sheave mentioned in Mr. Pratt's paper and the ordinary design, the variation of the angle

θ is about 3 per cent from that taken by a perfectly flexible band and the variation of the angle θ between that caused by a fully loaded car and an empty car is about $\frac{1}{2}$ of 1 per cent.

19 Since the amount of this inoperative tangency varies inversely as the square root of the tension of the cables we see that their rigidity does not materially affect the laws governing the friction drive or traction of the machine.

20 The bending of these cables of course lowers the mechanical efficiency of the machine, but we are entirely familiar with this consideration and do not need to investigate it at this time.

21 It is interesting to determine the conditions under which the cable works to the best advantage or when a due proportion of stress is caused by bending and tension respectively dependent upon the relative diameters of the cable wires and the driving sheave.

Let f be the total stress and f_b and f_t the stress caused by bending and the tension respectively,

$$\text{then } f = f_b + f_t \qquad [5]$$

22 The bending moment is $M = \frac{EI}{R}$ and also $M = f_b \frac{I}{\frac{1}{2}\delta}$ when δ, is the diameter of the wire. Equating these values $f_b = \frac{E\delta}{2R}$. If T is the total longitudinal tension in the rope of n wires each of δ inches diameter, then $f_t = \frac{T}{\frac{\pi}{4}\delta^2 n}$, and the total stress of the most strained wires is $f = \frac{E\delta}{2R} + \frac{T}{\frac{\pi}{4}\delta^2 n}$ hence,

$$T = \left(f - \frac{\delta E}{2R}\right)\frac{\pi}{4}\delta^2 n \qquad [6]$$

23 Differentiating and placing $\frac{dT}{d\delta} = 0$ we find $\frac{R}{\delta} = \frac{3E}{4f}$ or $R = 375$.

24 If the wire is $\frac{1}{2}$ inch diameter the diameter of the driving sheave would be $37\frac{1}{2}$ inches.

25 It has always been well known that the high speed electric elevator depends entirely upon friction for sustaining its load when at rest; but the extreme simplicity of the design of the traction ele-

vator reduces this friction to merely that of a brake and it brings this fact out prominently.

26 Before a wreck could occur from the failure of this friction brake on the machine, the emergency car brake, and the car safety device would also both have to fail and simultaneous failure of all these three devices is highly improbable; while terminal buffers control anything safely at the limits of travel except the most extraordinary car velocities.

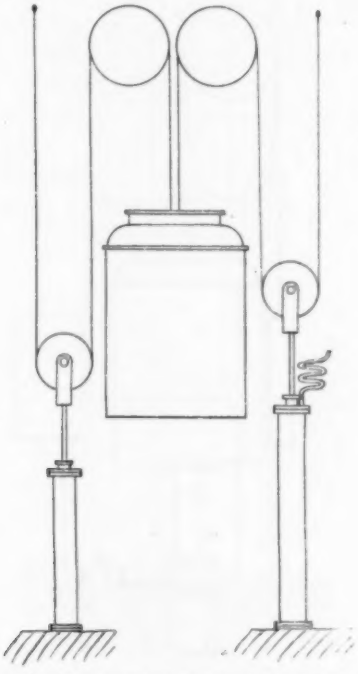

FIG. 3 SAFETY ELEVATOR DEMONSTRATED IN BROOKLYN

27 The machine would doubtless be improved by having, like a hydraulic elevator, a positive sustaining power; provided that disadvantages and complications are not introduced which more than offset any gain effected.

28 If all the good results, so fully mentioned by Mr. Pratt in his paper, are to be obtained by the use of his device, they can be demonstrated either by a sound and scientific mathematical treatment or by experiment and either way is equally conclusive for there is no conflict between true theory, worthy of the name, and experimental physics.

29 While he has given us much valuable matter in this paper it seems to be largely made up of predictions or prognostications of expected results based almost entirely on reasoning from analogy, which ignores exact conditions and the finer distinctions of governing laws, and is never of itself logically conclusive.

30 Opinions on such subjects often vary and demonstration by experiment is the only method of convincing all sorts and kinds of persons.

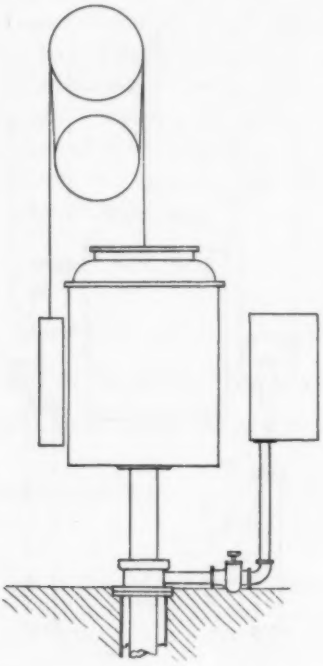

FIG. 4
TRACTION AND PLUNGER ELEVATOR RUNNING IN NEW YORK CITY

31 The only question involved, it seems to the writer, is that of safety for it is totally unnecessary to add a second motor to the apparatus in order to secure proper control.

32 It hardly seems necessary to discuss the elevator brought to our attention by Mr. Mabbs for every engineer can judge of its comparative complexity, and the space taken up by the machine extending up through the building and which must always be accessible at all points is of itself alone prohibitive. The writer has never seen any elevator driven by a rack and pinion from Hanford's elevator

years ago installed in the State House in Boston, Mass., and abandoned to the Mabbs elevator of today, in which the motion of the car is as smooth as he would wish in passenger elevator service.

33 The writer is unable to agree with Mr. Thomas E. Brown that the gearless traction drive elevator "has all the elements of safety and perfection of control of the hydraulic elevator" for a passenger car on one end of a set of cables and a heavy over-balance weight on the other end, causing the elevator to possess the quality of possibly

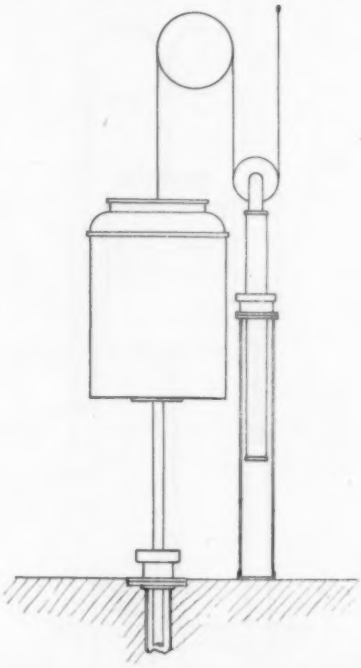

FIG. 5 ELEVATOR PROPOSED FOR METROPOLITAN TOWER

falling upwards as well as downwards, and with no sustaining power beyond a friction brake, cannot, from the very nature of the case, be considered as inherently safe as the hydraulic elevator.

34 The principle of duplication seems to have been carried to excess of late in the invention of safety devices as an inspection of several lately offered will show.

35 Fig. 3 represents a device which was demonstrated by experimental apparatus before an audience in the city of Brooklyn, and consists practically in adding to any elevator a Hale 2 to 1 vertical cylinder machine carrying the counterweight within it and operating upon

air which holds the car in case of falling by the compression caused by the resistance of its exit from this cylinder; this resistance being indicated in the sketch by the spiral coil of pipe above this cylinder.

36 Fig. 4 represents a gearless traction electric elevator with a plunger under the car which merely circulates the water to and from a supply tank for the sake of the safety supposed to be secured by such an operation as governed by the action of terminal stop valves operated by cables. It is in operation in a prominent building in New York City.

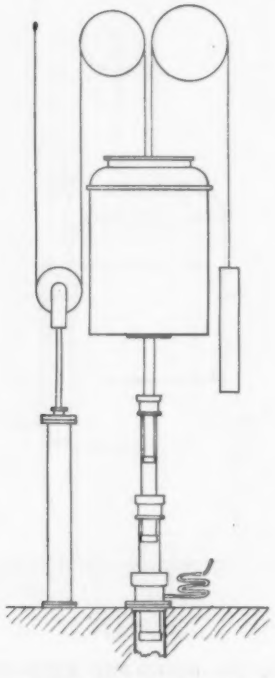

FIG. 6 TELESCOPIC ELEVATOR SAFETY

37 Fig. 5 represents the attachment to an ordinary plunger elevator of a Crane 2 to 1 gravity lifting plunger hydraulic elevator in the place of a counterweight in order that the mass of the counterweight may be controlled, that safe upward stops may be made on the plunger elevator, and the danger incident to pulling the car and plunger apart might be reduced to a minimum.

38 The writer is credibly informed that this construction was offered for the Metropolitan Life Insurance Co. Tower Building by advocates of the plunger elevator and it is evident in such a case that the Crane

2 to 1 elevator replacing the counterweight would do all the lifting and controlling while the plunger would simply dangle from the car in order to give an appearance of safety, while to proceed one step further, it is evident that the construction would be much improved by amputation of the plunger as close to the car as possible, for every engineer now knows that in the case of the high rise plunger elevator the lifting is really done by the massive iron counterweight which raises the car when the lower portion of the plunger is buoyed up by water pressure.

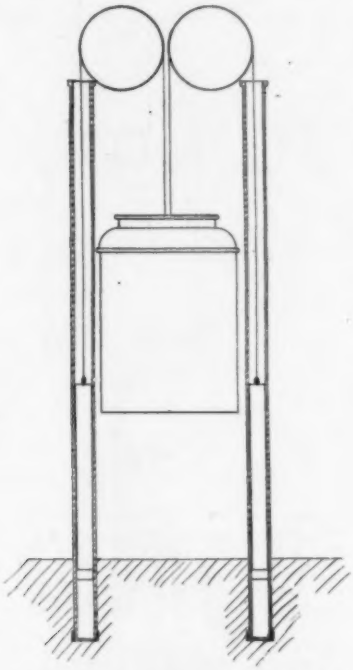

FIG. 7 AGGREGATION ELEVATOR ACTUALLY CONSTRUCTED

39 Fig. 6 represents the placing of a telescopic plunger elevator under any elevator car, to be operated by air, and to act as a safety device on the same principle as that shown in Fig. 1, the resistance to air exit being shown by spiral pipe as in Fig. 1.

40 Fig. 7 represents an elevator demonstrated by experimental apparatus in Philadelphia and from which extraordinary design actual machines have been built, as the writer is credibly informed. It consists of two lifting plungers which raise the load by their weight and are operated by hydraulic pressure under them in addition to

which an electric apparatus (not shown in the sketch) is attached to the overhead sheaves so that the car can be operated by this means also, or jointly by both. This device might justly be called the product of aggregation.

41 Fig. 8 represents the device offered by Mr. Pratt, which practically consists of adding a dead-lock worm gear elevator to the electric traction gearless elevator for the purpose of combining the advantages of these two machines.

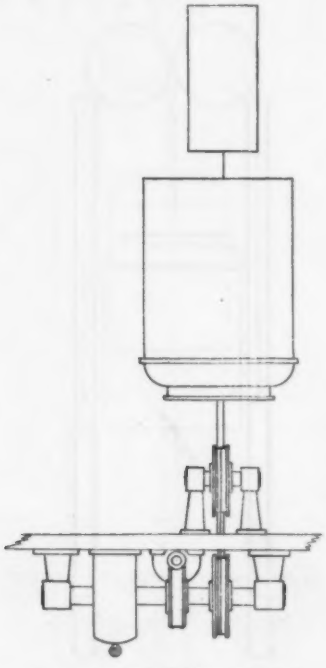

FIG. 8 THE PRATT DEVICE

42 Amid all this reduplication and aggregation, which cannot be called invention, we must not fail to remember that when we combine two or more elevator mechanisms we not only add their advantages but we also add their disadvantages, and that also incompatibility between some of the functions of these mechanisms may produce defects in the combination which neither of itself possessed.

43 The writer earnestly believes that better results will be obtained along the line of elevator progress by directing efforts in some other direction.

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